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Conceptual metaphor, human-computer interaction and music

Applying conceptual metaphor to the design and analysis of music interactions

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Abstract

Interaction design for domains that involve complex abstractions can present significant challenges. This problem is particularly acute in domains where users lack effective means to conceptualise and articulate relevant abstractions. In this thesis, we investigate the use of domain-specific conceptual metaphors to address the challenge of presenting complex abstractions, using tonal harmony as an extended case study.

This thesis presents a methodology for applying domain-specific conceptual metaphors to interactions designs for music. This domain involves complex abstractions where users with any degree of domain knowledge may have difficulty in articulating concepts. The methodology comprises several parts.

Firstly, the thesis explores methods for systematically guiding conversation between musicians to elicit speech that describes music using conceptual metaphors.

Recommendations for the most suitable methods are made.

Secondly, the thesis presents a methodology for identifying image schemas and conceptual metaphors from transcriptions of conversations between musicians. The methodology covers rules for identifying source image schemas and extrapolating conceptual metaphors.

Thirdly, the thesis presents a methodology for evaluating existing music interaction designs using domain-specific conceptual metaphors. We demonstrate that this approach can be used to identify potential areas for improvement as well as tensions in the design between certain tasks or abstractions.

Fourthly, the thesis presents a case study for the development of a conceptual metaphor-influenced design process. In the case study, a set of materials are developed to be used by participants in the design process to facilitate the mapping of conceptual metaphors to elements of an interaction design without requiring knowledge of Conceptual Metaphor Theory.

Finally, a pilot study is presented integrating the results of the conceptual metaphor-influenced design process into a consistent and useful prototype system. Compromises and refinements to the design proposals made during the design process are discussed and the resulting system design is detailed.

Declarations

Aspects of this work have been previously published in the following:

WILKIE, K., HOLLAND, S. and MULHOLLAND, P., 2013. Towards a participatory approach for interaction design based on conceptual metaphor theory: a case study from music interaction. In: S. HOLLAND, K. WILKIE, P. MULHOLLAND and A. SEAGO, eds, *Music and Human-Computer Interaction*. London: Springer, pp. 259–270.

WILKIE, K., HOLLAND, S. and MULHOLLAND, P., 2011. We can work it out: towards a participatory approach to designing music interactions. *Proceedings of the Workshop on “Music Interaction Design” at the British Computer Society HCI Conference 2011*, Newcastle Upon Tyne.

WILKIE, K., HOLLAND, S. and MULHOLLAND, P., 2010. What Can the Language of Musicians Tell Us about Music Interaction Design? *Computer Music Journal*, **34**(4), pp. 34–48.

WILKIE, K., HOLLAND, S. and MULHOLLAND, P., 2009. Analysis of conceptual metaphors to improve music software: the role of prior experience in inclusive music interaction. *Proceedings of the Workshop on “Prior Experience and Inclusive Design” at the British Computer Society HCI Conference 2009 Workshop*, Cambridge.

WILKIE, K., HOLLAND, S. and MULHOLLAND, P., 2009. Evaluating musical software using conceptual metaphors. *Proceedings of the British Computer Society HCI Conference 2009*, Cambridge. British Computer Society, pp. 232–237.

Elements of the present work appeared previously in the above as follows:

Figure 7:1 page 73, previously published in Wilkie et al. (2010). © The MIT Press 2010

Table 5:1 page 42, adapted from a version previously published in Wilkie et al. (2010). © The MIT Press 2010

Table 7:1 page 71, adapted from a version previously published in Wilkie et al. (2010). © The MIT Press 2010

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"We are starstuff. We are the universe made manifest, trying to figure itself out. And as we have both learned, sometimes the universe requires a change of perspective."

Straczynski, J. M. and Fontana D. C. (1994) Babylon 5. Episode. A Distant Star.

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1 Introduction

1.1 The Problem

Interaction design for domains that involve complex abstractions can present significant challenges. This problem is particularly acute in domains such as graphic design, desktop publishing or software development where users lack effective means or the ability to conceptualise and articulate relevant abstractions. This problem is compounded when mappings between domain-specific abstractions and elements of the interaction design are not immediately obvious to less experienced users. Such interaction designs are often aimed at experienced or professional users who have developed the required skills and knowledge to use these designs through detailed study, extensive experience or expensive training courses. Sadly, the requirement for in-depth knowledge can often deter all but the more experienced users and determined amateurs from carrying out more than a few rudimentary experiments and explorations with such interaction designs. Consequently, the need for interaction designs to present domain-specific information in a manner that is understandable and that enables users with any degree of domain knowledge to interact with effectively can pose a challenge for interaction designers.

Tonal harmony is an example of such a domain. This domain involves complex abstractions where users with any degree of domain knowledge may have difficulty in conceptualising, enacting or articulating relevant concepts. To use interaction designs for tonal harmony effectively often requires a detailed understanding of various domain-specific terminologies, processes, notations, concepts and rules. Existing software tools for these tasks often rely on the user's understanding of musical notation (e.g. Sibelius (Avid Technology Inc. 2011) and Finale (MakeMusic 2011)) or an ability to play a musical instrument or access to someone who does (e.g. GarageBand (Apple Inc. 2011) and Logic Pro (Apple Inc. 2011)). Even tools such as HarmonyBuilder (Musilogic Inc. 2013), that are specifically designed to assist with learning the principles of harmony and composition,

utilise music notation and numerous domain-specific terminologies. Consequently, without appropriate guidance (automated or otherwise), the less experienced user may lack confidence using such tools and thus generate harmonic progressions that lack harmonic structure and musical coherence. This research investigates whether it is possible to harness the detailed and, often tacit, domain knowledge acquired by musicians to address the challenge of presenting complex abstractions in interaction designs for carrying out tasks associated with tonal harmony.

1.2 A Potential Solution

Given the problem of investigating whether it is possible to harness domain knowledge to address the challenge of presenting complex abstractions in interaction designs, one promising solution is based upon the hypothesis that musical understanding is structured and underpinned by universal prior sensory-motor experiences (Brower 1997-1998, 2000, Johnson 1997-1998, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998). Specifically, this theory posits that understanding of abstract domains and concepts is grounded in recurring patterns of embodied experiences of space, forces and other bodies within our environment. These patterns are known as *image schemas* (Johnson 1987, p. 2, 2005, Lakoff and Núñez 2000, pp. 30-39). It is further posited (Johnson 1997-1998, 2005, Lakoff and Núñez 2000, pp. 39-45) that, in order to understand abstract concepts, we subconsciously map the applicable aspects of a source domain, which may be grounded in image-schematic experiences, onto the corresponding aspects of a target domain creating a *conceptual metaphor*.

Image schema and conceptual metaphor theories have previously been applied with some success to other domains. Lakoff and Núñez (2000) investigated the cognitive processes behind the creation of mathematical concepts and human mathematical abilities using image schema and conceptual metaphor theories. Similarly, a number of studies (e.g. Brower 1997-1998, 2000, Cox 2001, Eitan and Granot 2006, Eitan and Timmers 2010, Johnson 1997-1998, Johnson and Larson 2003, Larson 1997-1998, Larson and McAdams

2004, Larson and Vanhandel 2005, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998, 2009) have used image schema and conceptual metaphor theories to try to better explain aspects of musical cognition. Other research has used these theories to better understand the cognitive processes involved in philosophical thought (Lakoff and Johnson 1999). In addition to these contributions to cognitive science, there has been a limited amount of work applying image schema and conceptual metaphor theories to practical areas such as user interface and interaction design (e.g. Antle et al. 2009, Antle et al. 2009a, Antle et al. 2008, Hurtienne 2011, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Hurtienne et al. 2010, Rohrer 1995, Treglown 1999). While these works have established the viability of application in user interface and interaction design, the domains and tasks they have focused on do not pose any great difficulties for users to conceptualise, enact or articulate. By contrast, the present work deals with interaction designs for composing tonal harmonies. In this domain, the numerous concepts, terminologies, notations and processes can be difficult for users with any degree of experience to understand and for interaction designs to effectively communicate. In its most general form, the research question investigated in this thesis is, if we can identify the conceptual metaphors used to structure musicians' understanding of tonal harmony, can we harness this information to address the challenge of presenting complex abstractions within interaction designs such that they are useful and understandable to users with any degree of domain experience?

1.3 Research Questions

In order to further refine our previously stated general research question, we identified three subsidiary research questions. The context and motivation for these research questions and the approach we adopted to address each question is discussed further in chapter 4. However, we introduce them here for reference.

As the ability to identify conceptual metaphors relevant to music is an important prerequisite for our overall research purpose, a natural starting point for our thesis would

seem to be this identification process. The first research question, “How are conceptual metaphors revealed in conversations between musicians?” addresses a limitation in the current literature. Namely, that while there are studies analysing image schemas and conceptual metaphors found in *anecdotal utterances* (e.g. Johnson and Larson 2003, Larson 1997-1998) and *written texts of music theory* (e.g. Saslaw 1996, 1997-1998), there has been little work to systematically analyse *conversation between musicians*. Consequently, there has been little or no information on the extent to which the conceptual metaphors identified through analysis of music theory texts or anecdotal utterances reflect the thought processes used by musicians discussing and analysing music or preparing for performances.

The second research question, “What methods can be used to elicit conceptual metaphors relevant to music?” follows on naturally from the first. Through this research question we attempt to address a further limitation in the current literature. Specifically, despite some documented examples of elicitation techniques in other domains (e.g. Antle et al. 2009, Antle et al. 2009b, Antle et al. 2008, Bakker et al. 2009, Hurtienne 2011, Hurtienne et al. 2008), there is a general lack of information regarding the methodology used to elicit image schemas and conceptual metaphors associated with music in the current body of research (e.g. Johnson and Larson 2003, Larson 1997-1998).

Our final research question, “How can conceptual metaphors be used to inform interaction designs for music?” utilises the results of the previous two questions to explore how conceptual metaphors can be applied to both the analysis and design of music interactions. Although earlier studies applying image schema and conceptual metaphor theories to user interface and interaction design do exist (e.g. Antle et al. 2009, Antle et al. 2009b, Antle et al. 2008, Hurtienne 2011, Hurtienne et al. 2008, Hurtienne et al. 2010, Rohrer 1995, Treglown 1999), to the best of our knowledge, this is the first such research to apply these theories to interaction designs for complex musical concepts or for concepts that many potential users would be unable to conceptualise, enact or articulate.

1.4 Scope of Research

Music is a complex domain involving a number of different concepts including rhythm, melody, harmony, timbre, etc. As such, it was necessary to limit the scope of this research. Therefore, this research focuses specifically on interaction designs for composing tonal harmonic progressions.

1.5 Overview of the Thesis

This thesis is split into nine chapters as follows. Chapter 2 introduces the concept of tonal harmony and provides an overview of a number of existing examples of music software that may be used for composing tonal harmonic progressions. We briefly outline problems that may be faced by users when attempting to use such software.

Chapter 3 introduces the theories of image schema and conceptual metaphor upon which this research is based. We review various applications of these theories of particular relevance to this research. These applications include music theory and concepts, and, separately, user interface design and evaluation and interaction design.

In chapter 4 we discuss the three identified research questions in more detail, exploring the motivation and context for each question and briefly outlining our approach for addressing each question. We conclude this chapter with some comments on the methodological principles applied to this research.

Chapters 5 through 9 encompass the main body of this research. Chapter 5 addresses our first research question, “How are conceptual metaphors revealed in conversations between musicians?” This chapter reviews the results of a study designed to encourage conversations among musicians as they analyse an excerpt of music. This chapter also presents an initial methodology for the identification of relevant conceptual metaphors from conversations between musicians. This methodology is refined in chapter 6.

Our second research question, “What methods can be used to elicit conceptual metaphors relevant to music?” is addressed in chapter 6. This chapter reviews the results of two studies designed to investigate different methods of eliciting relevant conceptual

metaphors from conversations between musicians. We compare the different methods explored in both chapters 5 and 6, drawing some conclusions on which method is the most appropriate in the context within which this research is based. This chapter additionally provides a documented methodology for identifying conceptual metaphors relevant to music from conversations between musicians. This methodology is a refined version of the initial methodology detailed in chapter 5.

Our final research question, “How can conceptual metaphors be used to inform interaction designs for music?” is addressed in chapters 7 through 9. In chapter 7, we investigate how conceptual metaphors can be used to evaluate existing music interaction designs. This chapter reviews the results of a user interface evaluation study carried out using the set of conceptual metaphors identified during the study discussed in chapter 5. Two existing examples of music software are evaluated and the findings, along with potential opportunities to improve the interaction designs, are discussed.

Chapters 8 and 9 explore how conceptual metaphors can be used to inform the design new interactions for tonal harmony. In chapter 8, we review the results of a study asking musicians to design a wearable interactive gesture-controlled jumpsuit that enabled the wearer to create and modify harmonic progressions. We discuss the design of the study in detail, in particular the development of a set of supporting materials for the study that were based on conceptual metaphors. These materials provided a framework for the musicians to make their design proposals.

Chapter 9 draws on the results of the study discussed in chapter 8 to explore whether the design proposals made by the musicians could be integrated into a useful and usable prototype system for composing tonal harmonic progressions. The design and implementation of the prototype system is discussed including the justification for any design decisions and compromises made during the development of the prototype system. This chapter continues by documenting the results of a short study carried out to evaluate

the usefulness of the prototype system for creating tonal harmonic progressions. We conclude this chapter by reflecting on the design process for the prototype system.

In chapter 10, we conclude this thesis with a summary of the results of this research, reflecting on our findings. We highlight the contributions made to the literature and document the limitations of this research. We conclude this chapter with suggestions for future directions for this research.

2 Tonal Harmony and Music Software

2.1 Introduction

Tonal harmony is generally considered a complex domain to grasp, even for the experienced musician. A true understanding of the principles of tonal harmony requires extensive knowledge of domain-specific concepts, terminologies, processes, rules and notations. Such understanding is often only acquired through rigorous academic study, learning and applying the rules laid down by theorists and composers (e.g. Rameau 1971, Schenker 1980, Schoenberg 1978) over the last few hundred years. Sadly, the requirement for such in-depth knowledge often precludes all but the more experienced musicians and enthusiastic amateurs from engaging in tasks involving tonal harmony, for example musical analysis, arrangement and many kinds of composition. As a consequence, the design of interactions for music software remains an open challenge – particularly if one wishes to empower users with any degree of domain knowledge to engage in depth with musical and harmonic structures, while still satisfying the more specialised requirements of experienced users. It is the broad aim of this research to explore whether the application of conceptual metaphors to the analysis and design of music interactions for tonal harmony can help to address the challenge of presenting complex abstractions associated with tonal harmony. In order to provide a context for this research, we begin by briefly outlining some of the principles of tonal harmony. We then continue in the sections below by reviewing some representative examples of existing music software that can be used for composing in general and for composing tonal harmonic progressions in particular.

2.2 Principles of Tonal Harmony

In music, harmony defines the structure of and relationships between musical chords. The system of *tonal harmony* in particular, is concerned with the relationships between the *tonic chord* and the six chords that form part of the same key. A sequential series of chords that form a piece of music is known as a *chord sequence* or a *harmonic progression*.

Although a piece of music will start in one key, it is common practice to move or *modulate* to other keys, thus changing the tonic chord. Modulation can be achieved through the use of pre-defined structures known as *cadences*. Figure 2:1 below shows an example of a simple modulation from the initial key of C major to the new key of G major (as indicated by the change in key signature at the beginning of the final bar). The example illustrates the use of what is known as a *perfect cadence*, which is a way of using two chords that stand in a particular harmonic relationship to each other, and to the key of the progression, in order to end a piece or fragment in a harmonically satisfactory manner. The example utilises the following chord progression:

C major – F major – G major – A minor – D major – G major



Figure 2:1 - Example of a simple modulation from C major to G major. The sequence D major to G major illustrates the use of a perfect cadence. Previously published in Wilkie et al. (2013).

In a piece of music, the different notes that form part of a chord may be split across multiple instruments or, in the case of polyphonic instruments such as the piano, the notes may be controlled by different hands. This split implicitly leads to the concept of *voice leading*, where multiple lines of music each have their own identity but also interact with each other to produce a unified harmonic whole.

There are various rules that define aspects of tonal harmony. Good examples of such aspects include how one key may modulate to another through the use of cadences, the appropriate contexts within which a specific chord can be used and how multiple lines of music may interact with each other. Numerous music theorists and composers have documented these rules (e.g. Rameau 1971, Schoenberg 1978), along with frameworks that can be used to analyse music and harmony (e.g. Lerdahl and Jackendoff 1983, Schenker

1980). However, without a basic grasp of these rules, creating structurally coherent and pleasing tonal harmonic progressions is likely to be challenging, even for a musician.

2.2.1 Systems of Notation

Although to the trained eye, harmonic progressions can be identified in standard music notation through examining the structure of the various parts, additional notations are often used when describing and analysing harmonic progressions. Examples of these include chord names (as shown above in relation to figure 2:1), roman numerals and, for Baroque music in particular, figured bass (e.g. Ledbetter 1990). Although the ability to understand and use these notations is not essential when composing tonal harmonic progressions per se, theoretical texts and certain music software (e.g. Harmony Builder (Musilogic Inc. 2013)) will make extensive use of these, and other, notations. Thus the student who wishes to better understand the processes and rules involved in tonal harmony or utilise such software effectively would generally need to learn some of the more commonly used notation systems.

2.3 Software for Composing Music

Numerous software applications have been developed to cater for various musical tasks including, but not limited to, performance, composition and musical arrangement, sequencing, production, notation, generation, live coding and analysis. Some of these applications are free to download while others are only available commercially. Software applications for composing in particular generally fall into one of the three broad categories based on the functionality they provide¹:

1. Music sequencing, recording and production (including digital audio workstations)
2. Music notation
3. Music generation and performance

A composer may use one or more software applications (possibly from different categories) depending on the music they wish to compose and their own personal

¹ As one application may incorporate functionality from more than one category, we have categorised the applications based on their primary function.

preferences. We briefly review some representative examples of such software, highlighting general usability and accessibility issues that may be encountered by users who lack experience in these tools or who have limited understanding of the domain.

2.3.1 Music Sequencing, Recording and Production Software

Music sequencing, recording and production software provide facilities to record and produce music, incorporating features such as MIDI and audio sequencing, track mixing and the ability to apply effects such as reverb, filters and fades. In general, such software allows the user to record a series of parts, or tracks, which can then be mixed together to form a complete composition, applying effects where required. External instruments are often used to provide the MIDI and/or audio input for the tracks (although built in MIDI instruments and/or editors can be provided), setting an expectation that users of such software will be able to play one or more instruments or, at the very least, have access to people who do. The best-known commercially available applications of this kind include Logic Pro (Apple Inc. 2012), Pro Tools (Avid Technology Inc. 2013) and Ableton Live (Ableton 2013). However, as McDermott et al. (2013) observes, such software often provides so much functionality that users may have difficulty locating the desired function. They also note that many musicians avoid direct use of such software, relying on others to record and produce their music. This perhaps suggests that knowledge of music does not necessarily equate to understanding of the concepts and abstractions associated with using such software.

In contrast GarageBand (Apple Inc. 2011), included as part of Apple's iLife suite, provides basic sequencing, recording and production functionality in a format that is more accessible to beginners (McDermott et al. 2013). However, as with more fully featured software, audio or MIDI input from instruments is still required unless prefabricated samples are used, thus effectively avoiding any fine-grained effort at composition. GarageBand attempts to address this by including instrument lessons and backing band features. Nonetheless, some basic grasp of the principles of recording, mixing and

production are still required to utilise the software to its fullest potential. Such

prerequisites may discourage all but the most enthusiastic user from using such software.

2.3.2 Music Notation Software

Music notation software is used to produce sheet music for performance. In general, the user will add notes, rests and other notation symbols to an on-screen score by selecting from a palette or by playing the notes on a MIDI keyboard. Such an approach is more familiar to traditionally trained musicians with an in depth understanding of music notation and theory, thus is much less accessible to domain novices.

Various commercial notation software applications exist including Sibelius (Avid Technology Inc. 2011) and Finale (MakeMusic 2011). However, LilyPond, released under the GNU General Public License (2013a), takes a different approach to producing scores. The user must create a text file describing the structure, layout and contents of the score using specified syntax and grammars. The software then parses the text file and produces a score. Thus, the user not only needs to understand the notation they are working with, they must also understand the text syntax and grammars and how best to utilise these to produce the layout they want. Powerful though such software applications are, the pre-requisite for understanding music notation effectively excludes users with limited knowledge of music notation from using them to compose music.

2.3.3 Music Generation and Performance Software

Music generation and performance software is used to generate music, possibly as part of an improvisatory process, and may be used as an instrument for performance in its own right. Such applications often use a form of visual or textual programming where the user must connect symbols together or write simple code to generate musical patterns and often include sound processing functionality. A number of such applications exist including Max (Cycling '74 2013), Pure Data (Puckette 2013) and SuperCollider (GNU General Public License 2013b). Although such software encourages a more experimental and improvisatory approach to composition thus on the surface appearing more accessible to

the domain novice, the requirement to learn and understand a programming language in order to use the software to its full potential may be a barrier to many users.

In contrast to the aforementioned desktop-based applications, Reactable (Jordà et al. 2012) has a tangible interface and is designed for collaborative interactions (Kaltenbrunner et al. 2006). Music is generated by moving objects, which represent components of a synthesizer, around a table. The authors estimate that, based on the feedback received from Reactable installations, users are able to pick up the basic principles in around 10 minutes and frequently return to try using the installation again (Jordà et al. 2007). Unfortunately, the size and cost of a Reactable is likely to be prohibitive to the majority of users, although a more affordable and practical mobile version (Jordà et al. 2010) does exist. However, despite Reactable's more accessible interface, and similar to the other examples of music generation and performance software mentioned above, it is designed for composing electronic music with an emphasis on timbral aspects and does not generally lend itself to composing music involving tonal harmonic progressions.

2.4 Summary

In this chapter we have briefly reviewed the principles of tonal harmony. We have also reviewed some examples of existing software that may be used to compose tonal harmonic progressions noting some of the usability and accessibility issues that users with any degree of domain experience may encounter when using such software. In the following chapter we introduce the theory of embodied universal knowledge upon which this research is based.

3 Embodied Understanding

3.1 Introduction

In the previous chapter, we reviewed some representative examples of software applications that could be used for composing tonal harmonic progressions noting various usability and accessibility issues that users may encounter when attempting to use such software. The majority of the examples we reviewed required some understanding of musical concepts to utilise the software to its full potential. This highlights a need to find alternative ways of expressing complex domain abstractions in a form that is more accessible and understandable to users with any degree of domain knowledge.

One promising theory of musical understanding is based upon the hypothesis that conceptual knowledge is structured and underpinned by universal prior sensory-motor experiences (Brower 1997-1998, 2000, Johnson 1997-1998, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998). Specifically, this theory posits that understanding of abstract domains and concepts is grounded in recurring patterns of embodied experiences of space, forces and other bodies within our environment known as *image schemas* (Johnson 1987, p. 2, 2005, Lakoff and Núñez 2000, pp. 30-39). Although the use of the term “image” may imply a visual emphasis, image schemas are claimed to be schematic representations of abstracted universal embodied experiences (Grady 2005, Rohrer 2005)² from any sensory modality or motor experience (Hurtienne 2011). Furthermore, a vital part of any image schema is that it is held to be universal, or quasi-universal, if specialised. Thus, it is important not to confuse image schemas with conscious mental images of specific objects or experiences, such as a mental image of a beach one has visited or seen on TV or in a book where the visual content, rather than being universal, would be specific to the person viewing (Grady 2005). (A number of examples of previously catalogued image schemas are given later in this chapter.)

² The terms “embodied” and “embodiment” have many uses in cognitive science (Rohrer 2007). For the purposes of this research, we use the terms “embodied” and “embodiment” to refer to sensory-motor experiences, for example gravity, height, momentum, containment, orientation, etc.

Despite the association between image schemas and embodied experiences, many of the image schemas catalogued by Hurtienne (2011) such as CYCLE and LINK may at first glance appear distant from embodied or perceptual experiences. Grady (2005) observes that although not all image schemas are defined by perceptual experiences per se, they can be related to and experienced in terms of bodily experiences (for example the CYCLE image schema is experienced during breathing). He argues that a more appropriate definition for image schemas would be “mental representations of fundamental units of sensory experience”. However, for the purposes of this research, we accept Johnson’s (2005) characterisation of image schemas:

“...image schemas are the recurring patterns of our sensory-motor experience by means of which we can make sense of the experience and reason about it, and that can also be recruited to structure abstract concepts and to carry out inferences about abstract domains of thought.” (Johnson 2005)

One of the main sources of evidence for the existence of image schemas, as well as a principal means for the discovery and characterisation of specific image schemas, is the analysis of linguistic expressions in spoken or written text. As an example, consider the CONTAINER image schema which represents numerous everyday experiences of containment such as filling a tub with water, putting an object into a box or moving from one room into another (Johnson 1987, pp. 21-23, Lakoff and Johnson 2003, pp. 29-32). The CONTAINER image schema (see figure 3:1 below) is a gestalt grouping comprising of an interior, exterior and boundary parts (Lakoff and Núñez 2000, pp. 30-34). It is posited (Lakoff and Núñez 2000, pp. 30-31) that containment is often indicated in the English language by the use of the prepositions “in” and “out”, for example “the clothes are *in* the wardrobe”, “the music computing students are *in* the faculty of computing”, “the phrase is *in* the key of G major” and “take the cake *out* of the oven”. Considering the example phrases above further, we can see that the CONTAINER image schema can be used both in contexts where the container object is a tangible entity (“the clothes are *in* the *wardrobe*”) but also by contrast in contexts where the container object is a conceptual abstraction (“the phrase is *in* the key of *G major*”). Furthermore, we can see that the

inherent structure of the CONTAINER image schema gives rise to a series of entailments that can be used to carry out spatial reasoning operations (Johnson 2005, Lakoff and Núñez 2000, pp. 30-34). For example if object A resides within CONTAINER X and CONTAINER X resides within CONTAINER Y, we can deduce that object A also resides in CONTAINER Y (see figure 3:2 below).

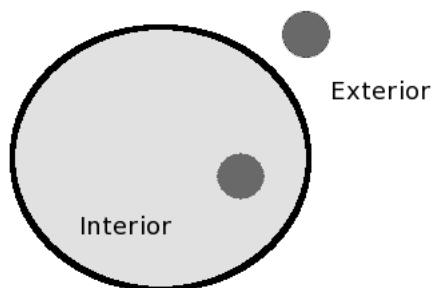


Figure 3:1 - Representation of the CONTAINER image schema showing the interior and exterior of the CONTAINER. The boundary is represented by the black outline. The representation also shows two objects, one inside and one outside the CONTAINER.

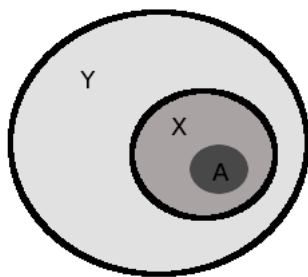


Figure 3:2 - Representation of the CONTAINER image schema showing object A residing in both CONTAINER X and CONTAINER Y.

3.1.1 Understanding Abstract Concepts

It is posited (Johnson 1997-1998, 2005, Lakoff and Núñez 2000, pp. 39-45) that in order to understand abstract concepts, we subconsciously map the applicable aspects of a source domain onto the corresponding aspects of a target domain creating a *conceptual metaphor*. Johnson (1997-1998) characterises the process of mapping structure from the source domain to the abstract target domain as follows:

“A conceptual metaphor is a cross-domain mapping of entities and structures from a source domain onto a target domain. Via mappings of this sort, we can use our understanding of the bodily source domain (such as motion through space) to reason about some abstract target domain (such as abstract reasoning). We appropriate our knowledge of the source domain to construct parallel knowledge claims about the target domain. In this way even our most abstract concepts are tied via metaphor to embodied meaning structures.” (Johnson 1997-1998)

Further classifications of conceptual metaphors have been posited. **Primary metaphors** are grounded in image-schematic source experiences such as verticality, weight, force, etc and are thought to be universal and widespread across languages and cultures (Grady 2007, Lakoff and Johnson 1999, pp. 45-59). For example, mapping image-schematic experiences of this kind onto abstract concepts, such as quality or emotion, results in primary metaphors such as MORE IS UP (Grady 2007, Lakoff and Johnson 1999, pp. 45-59). **Complex metaphors**, for example THEORIES ARE BUILDINGS, are elaborations of primary metaphors and map concepts from one non-perceptual domain to another (Grady 2007, Lakoff and Johnson 1999, pp. 45-73). However, such metaphors can still be analysed in terms of perceptual experiences. In the case of the complex metaphor THEORIES ARE BUILDINGS, Grady (2007) posits that the logical organisation of theories is understood in terms of a physical structure. A third classification of conceptual metaphors, **novel metaphors**, are representative of the sort of metaphorical mappings that are often referred to as ‘metaphors’ in general conversation (Lakoff 1993). This classification includes analogies, poetic metaphors and **image metaphors**. Image metaphors map one mental image onto another (Lakoff 1993), for example likening a person’s eyes to sparkling diamonds. This research is concerned with the identification and application of primary and complex metaphors relevant to musical concepts. However, for clarity, we do not make a distinction between these two classifications and use the more general term conceptual metaphor.

As music is a complex domain encompassing many concepts such as pitch, melody, rhythm, harmony, etc, the opportunities for metaphorical mappings resulting in primary, complex and novel metaphors are numerous. For example, as noted earlier, when we refer to a musical phrase being in a specific key, “the phrase is *in* the key of G major”, we are mapping the CONTAINER image schema onto the concept of musical key, creating the

conceptual metaphor A KEY IS A CONTAINER FOR A MUSICAL PHRASE³. In a further example, Zbikowski (1997, 1997-1998, 2008) notes that musical pitch is often described in terms of height, illustrating this in terms of the VERITICALITY (referred to by Hurtienne (2011) as UP-DOWN) image schema. Reflecting on this common mapping between height and pitch, Cox (2001) argues that musical pitches do not have a height *per se* and posits that this commonly used metaphorical mapping is instead grounded in our experiences of vocalising sounds; higher sounds require a greater volume of air and more effort and tension than lower sounds. This would seem to imply a conceptual metaphor such as HIGH PITCH IS GREATER/LOW PITCH IS LESSER would be more prevalent in linguistic expressions. However, Cox goes on to argue that the conceptual metaphor GREATER IS HIGHER is used as a bridge to enable pitch to be understood in terms of height. In any event, the conceptual metaphor HIGH PITCH IS UP/LOW PITCH IS DOWN does seem to be pervasive in Western music, particularly when we consider that pitch is represented on a vertical scale of staves lines in musical notation.

Returning again to the phrase “the phrase is *in* the key of G major”, we can see that the spatial logic inherent in the CONTAINER image schema can also be applied to the target domain, in this case musical key. For example, if the note B appears in the chord of G major and the chord of G major is used within the musical phrase, we can deduce that the note B also appears in the musical phrase. However, it is important to note that this transitivity only occurs when the image schematic relationships are applied to the same domain. For example, if the chord of F major is used *in* a piece of music and that piece of music is *in* a Baroque style, it does not follow that the chord of F major is *in* the Baroque style. In this scenario, although musical key and musical style are both components of the general domain of music, they are different concepts and thus transitivity is not possible.

³ Zbikowski (2009) raises the interesting question of whether music could be considered a source domain in some contexts. For the purposes of this research, music and musical concepts such as tonal harmony will always be regarded as the target domain and we will not consider the influence of music on other domains.

Metaphorical mappings such as those described above are constrained by what has been termed as the ***Invariance Principle*** (Grady 2007, Lakoff 1990, 1993, Turner 1990). The Invariance Principle ensures that correspondences between the source and the target domain are retained. For example, unlike fruit, both height and pitch can be split into discrete units of measurement, thus explaining why height is a better fit for pitch than fruit (Zbikowski 1997-1998).

3.1.2 Other Linguistic Structures and Related Theories

It is important not to confuse conceptual metaphor with linguistic structures such as metonymy (where one object is used to refer to another) and synecdoche (a special case of metonymy where one or more objects which form part of an object structure are used to refer to the object structure itself) (Lakoff and Johnson 2003, pp. 35-36). Although both synecdoche and conceptual metaphor can be identified in the phrase “*the flute comes in* at bar 13”, they are used in different ways. The preposition “in” indicates the use of the CONTAINER image schema as discussed previously while the use of the term “flute” is synecdochical and refers to the group of flute players. Synecdoche and metonymy will not be considered in this research.

Related but distinct from Conceptual Metaphor Theory is the theory of ***conceptual blending*** (Grady et al. 1999, Turner and Fauconnier 1995). Conceptual metaphors involve two domains, a source and a target. On the other hand, the theory of conceptual blending (Grady et al. 1999, Turner and Fauconnier 1995) involves four or more spaces, two input spaces (the source and target in Conceptual Metaphor Theory (Grady et al. 1999)), a generic space (containing the structure common to both the source and target spaces) and a blended space upon which the structure from both input spaces is projected. This present research focuses specifically on the application of Conceptual Metaphor Theory to inform the design of music interactions and Conceptual Blending Theory will not be considered

further⁴. However, it is interesting to note that Grady et al. (1999) hypothesise that primary metaphors are involved in conceptual blending to create complex metaphors.

3.2 Applying Embodied Knowledge

Image schema and conceptual metaphor theories have already been applied with some success to other domains including mathematical structures and concepts (Lakoff and Núñez 2000), philosophy (Lakoff and Johnson 1999) and Java programming language documentation (Blackwell 2006a). Applications with particular relevance to this research include:

1. Music theory and concepts (Brower 1997-1998, 2000, Cox 2001, Eitan and Granot 2006, Eitan and Timmers 2010, Johnson 1997-1998, Johnson and Larson 2003, Larson 1997-1998, Larson and McAdams 2004, Larson and Vanhandel 2005, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998, 2009).
2. User interface design and evaluation (Hurtienne 2011, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Rohrer 1995, Treglown 1999).
3. Interaction design (Antle 2009, Antle et al. 2009, Antle et al. 2009a, Antle et al. 2008, Bakker et al. 2009, Hurtienne et al. 2010).

These applications will be discussed further in the sections below. For the purposes of this research we distinguish between user interface design and interaction design. We define interaction design as the method by which the user interacts with a system, for example keyboard and mouse, gesture, touch, etc, and user interface design as encompassing the user interface controls such as buttons, labels, text boxes as well as the layout, behaviour and terminology used in the user interface.

3.2.1 Embodied Knowledge and Musical Concepts

In general, two main approaches have been taken when applying embodied theories to musical concepts:

⁴ For a discussion on the application of Conceptual Blending Theory to music theory and text painting in particular, see Zbikowski (2008).

1. Analyses of how musical concepts can be explained by embodied theories. This approach often makes reference to various texts written by music theorists.
2. Experiment-based approaches to identifying and validating musical concepts in terms of embodied theories.

Both these approaches are discussed in the sections below.

3.2.1.1 How can Embodied Theories Explain Musical Concepts?

Analysing the language used by Riemann in his “Systematic study of Modulation as a Foundation for the Study of Musical Form, Saslaw (1996) argues that Riemann understands harmonic and cadential progressions in terms of the CONTAINER, PATH and FORCE image schemas. Specifically, Saslaw posits that Riemann’s understanding of modulation requires a FORCE image schema to move from one key CONTAINER to the next. In a further example, Saslaw (1997-1998) presents a detailed analysis of Schenker’s “Free Composition” and Schoenberg’s “The Musical Idea and the Logic, Technique, and Art of its Presentation” arguing that though the theories differ, they can both be attributed to experiences of physical forces. Saslaw concludes by providing a brief analysis of Schenker’s notation system for describing the essential structural elements of a piece of music, identifying examples of the CONTAINER and SOURCE-PATH-GOAL image schemas in the notation.

Comprehensive though Saslaw’s (1996, 1997-1998) studies are, their primary focus is on the image-schematic understanding of musical phenomena as described by music theorists. In a contrasting study, Larson (1997-1998) argues that the forces exerted by the musical equivalent of gravity, inertia and magnetism influence the structure of melodic patterns. As an example, Larson posits that a melodic pattern starting on note degree 5 and moving to note degree 4 will be influenced by gravity, downwards inertia and magnetism, which will encourage resolution to the nearest stable pitch, and thus conclude on note degree 3. His hypothesis is particularly interesting for this research as it suggests that

embodied experience exerts an influence not only on our understanding of musical concepts but also on the compositional process itself.

Concurring with Larson's (1997-1998) view that melodic patterns are influenced by inertia and gravity, Brower (1997-1998) argues that our experiences of balance and the desire for stability accounts for the 'pull' towards a stable pitch rather than the force of magnetism. She further hypothesises that musical goals are analogous to goals in the physical world where diversion from the path towards a physical or musical goal results in a desire to return to that path. Brower applies these theories by analysing the first seventeen bars of Varèse's *Density 21.5* in terms of the image-schematic concepts of BALANCE, PATH and CONTAINER and comparing this analysis with metaphorical descriptions of the piece given by other theorists. She concludes that image-schematic analysis can account for a number of the metaphorical descriptions thus indicating that they were influenced by embodied experiences.

Expanding upon the work of Saslaw (1996, 1997-1998) and Larson (1997-1998), Brower (2000) hypothesises that meaning in music arises through mapping heard patterns within music onto three types of patterns: patterns within the music itself; patterns based on musical conventions and image-schematic patterns grounded in embodied experiences. Identifying the CONTAINER, CYCLE, VERTICALITY (UP-DOWN), BALANCE, CENTRE-PERIPHERY and SOURCE-PATH-GOAL image schemas as central to our understanding of musical concepts, Brower posits how these may be combined to structure our understanding of musical conventions such as the resolution of pitches and harmonic relationships including the cycle of fifths. Likening modulation to the pull of gravity, and expanding further on her earlier hypothesis (Brower 1997-1998) that our experiences of balance can account for a tendency to move towards a stable pitch, Brower hypothesises that we realign our harmonic centre of gravity to maintain stability within the current harmonic context, similar to adapting our body's centre of gravity while moving.

Focusing on the broader association between music and movement, Johnson and Larson (2003) identify three conceptual metaphors that they hypothesise define the experience of musical motion: MUSICAL LANDSCAPE, MOVING MUSIC and MUSIC AS MOVING FORCE. Arguing that these conceptual metaphors are underpinned by our understanding of time and past and future events, they cite correspondences between the two domains, for example likening a musical event to a physical object in space, tempo to speed of motion and a listener to a traveller moving within a landscape. Johnson and Larson provide a number of examples of linguistic expressions and song lyrics to illustrate their hypothesis; however, it is unclear how the linguistic expressions were obtained.

Despite providing examples of how musical concepts can be explained in terms of embodied experiences, the majority of evidence provided in the studies discussed above is focussed on the identification of image schemas and conceptual metaphors in theoretical texts. Only Larson (1997-1998) and Johnson in conjunction with Larson (2003) cite a significant number of examples of linguistic expressions that we may reasonably expect to hear in conversations between musicians. Despite this, neither study provides any detail of the context within which the expressions were identified or any information on the methodology used to identify and validate them, a general concern with such studies that is discussed further by Hurtienne (2011). This research will attempt to address this issue in part by running studies with musicians to firstly identify how conceptual metaphors are revealed in conversations and, secondly, to explore methods for eliciting conceptual metaphors.

3.2.1.2 Verifying Embodied Understanding of Musical Concepts

Exploring the relationship between musical parameters such as pitch, articulation, dynamics, etc. and motion, Eitan and Granot (2006) carried out studies asking participants to describe short musical stimuli in terms of the motion of an imagined character. The musical stimuli took the form of pairs of short melodic patterns, where each pair consisted of an example of an increase in a parameter, e.g. crescendo, and an example of a decrease

in a parameter, e.g. *diminuendo*. Their results revealed that in general, a change in parameter was associated with a change in motion. However, their initial hypothesis that if an increase in a particular parameter was associated with a specific motion, a decrease in the same parameter should be associated with the inverse motion, was not fully supported. For example, although pitch descent was strongly associated with descending motion, the association between pitch ascent and ascending motion was weaker suggesting that the association between height and pitch is not necessarily universally shared. This is perhaps unexpected when we consider the common association between pitch and height in Western music (Zbikowski 1997, 1997-1998, 1998, 2008) but not surprising when we consider that this association is not reflected across all cultures. In other cultures, pitch is variously described in terms of “small” and “large”, “young” and “old” and “crocodiles” and “those who follow crocodiles” (Eitan and Timmers 2010, Zbikowski 1997, 1997-1998, 1998, 2008). If we accept the hypothesis that abstract concepts such as pitch are grounded in image schemas (Brower 2000, Johnson 1997-1998, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998), the various mappings for pitch would suggest that there should be a more fundamental mapping or primary metaphor upon which pitch is understood (Eitan and Timmers 2010).

Attempting to validate whether Western participants could understand pitch mappings from other cultures, Eitan and Timmers (2010) carried out studies with participants with varying levels of musical training. They provided the participants with a series of pairs of antonyms based on pitch mappings from different cultures and asked them to select the most appropriate term out of each pair to describe firstly, pitch, and secondly, excerpts from a Beethoven piano sonata. In addition, they also carried out a second task for comparison, asking a control group of participants to select the most appropriate term out of each pair of antonyms to describe spatial height. While the results revealed that a significant number of Western participants were able to correctly apply pitch mappings from other cultures supporting the hypothesis of a lower-level universal

pitch mapping, the results also indicated that although increasing spatial height is associated with *increasing* size or quantity, increasing pitch is associated with *decreasing* size. Taken in context with the results of Eitan and Grant's work (2006), this suggests that the associations between pitch, space and motion could be more complex than initially assumed. Furthermore, both sets of studies (Eitan and Granot 2006, Eitan and Timmers 2010) were restricted to basic musical parameters and did not include an exploration of harmonic concepts. Thus, further work is needed to establish the extent and depth to which musical concepts such as harmonic theory and concepts can be explained by embodied theories. Although this present research does not attempt to address these issues in detail, we do provide additional examples of how conceptual metaphors can be used to explain musicians' understanding of musical concepts and tonal harmony in particular.

Expanding on Larson's (1997-1998) theories of the influence of the forces of gravity, magnetism and inertia within melodic patterns, Larson and VanHandel (2005) explored whether these forces could contribute to listeners' judgements of melodic pattern completion. They identified sixteen three-note melodic patterns (eight within a minor context and eight within a major context) and grouped these into pairs based on the opening two notes. For example, the two-note opening 1-2 gives rise to two possible completions, 1-2-1 and 1-2-3. Each pattern was then scored based on its support for the three forces. For example, the pattern 1-2-1 received a score of 1 for gravity (as it descends back to note 1) and 0 for inertia (as it descends rather than rises to note 3) and 0 for magnetism (as the difference between note 2 and 1 is a whole tone). Participants were then asked to rate the pairs of patterns based on how well the second note 'led' to the third note within a specified tonal context. Statistical analysis of the participants' responses combined with the scores assigned to each pattern revealed their hypothesis was partially supported, but indicated that the influence of inertia was stronger than the other two forces. This conclusion is particularly interesting as it provides some empirical support for the hypothesis that our understanding of musical concepts is grounded in embodied

experiences (Brower 1997-1998, 2000, Johnson 1997-1998, Saslaw 1996, 1997-1998,

Zbikowski 1997, 1997-1998) albeit restricted to the structure of melodic patterns.

3.2.2 Embodied Knowledge and User Interface Design

Metaphor, or what would be more correctly referred to as novel metaphor in Conceptual Metaphor Theory, is often recommended to user interface designers as a tool to assist users in transferring existing knowledge from one (possibly paper-based) system to another (e.g. Madsen 1994, Minocha and Woodroffe 2001, Preece et al. 1994, pp. 141-154). For example, users' experiences of using a paper-based calendar may be used to inform the design of a computerised calendar system by retaining the month-by-month view and the ability to enter event information for a specific day. Despite this, a number of problems have been documented with this approach, for example when the metaphorical mapping between the two versions of the system is broken by additional functionality that was not available in the original system or the redesigned system forces a (potentially contradictory) change in the user's mental model when carrying out a specific task (e.g. Blackwell 2006b, Halasz and Moran 1982, Rohrer 1995, Treglown 1999). Although Lakoff and Johnson's (2003) seminal work is often acknowledged in the HCI and design fields (e.g. Preece et al. 1994, p. 153, Halasz and Moran 1982, Madsen 1994), systematic applications of Conceptual Metaphor and Image Schema Theory as a technique to inform user interface designs are less common. This disparity is noted by Treglown (2004) who, when reviewing a workshop on the topic of metaphor in HCI, comments that "the application and impact of whose [Lakoff and Johnson's] ideas in HCI do not seem to be thought through as often as the book is cited". Blackwell (2006b) provides a brief overview of the influence and potential implications of conceptual metaphor and embodied theories within the context of metaphor as a design tool. However, his comment that "any abstract concept can be shown to depend on mental images" when summarising Lakoff and Johnson's work could be considered potentially misleading when taken into account with Grady's (2005) concern that image schemas should not be confused with mental images of

more concrete objects such as beaches as noted earlier in this chapter. Nevertheless, Blackwell observed that the influence of Lakoff and Johnson's theories on HCI was a particular concern to the participants of the workshop that he and Treglown (2004) attended. We briefly review a number of the more systematic approaches to applying image schema and conceptual metaphor theories to user interface design below.

Arguing that the use of analogies and metaphors in user interface designs can often result in difficulties for users, Treglown (1999) hypothesises that image schema and conceptual metaphor theories can be used to analyse existing user interface designs and account for users' understanding of the user interfaces and some of the problems that can arise. Presenting three short case studies, one of which is a brief discussion of an earlier study by Rohrer (1995), he uses image schema and conceptual metaphor theories to explore aspects of three interaction models, concluding that the approach proved useful. However, his approach to the analysis was limited to identifying the image schemas and conceptual metaphors exposed by the interaction models and discussing whether these can account for users' understanding of the models. Although this approach demonstrates the potential for using image schemas and conceptual metaphors as a tool for user interface evaluation, it primarily relies on the evaluator's perception of what constitutes users' conceptual understanding of the concepts and tasks afforded by the interaction model.

Expanding his hypothesis to include the use of image schema and conceptual metaphor theories as a tool for designing user interfaces, Treglown (1999) then presents a revised version of his Medusa file management and operating system based on image schema and conceptual metaphor theories. Discussing the various image schemas and conceptual metaphors employed in the revised version of the system, his work provides an early example of mapping image schemas and conceptual metaphors derived from dialogue transcriptions and descriptions of users' working practices to aspects of an interaction model.

Exploring the potential of using image schemas as a tool for making design

decisions, Hurtienne and Blessing (2007) designed experiments to test whether user interface controls configured to support specific image schemas would be more usable. In the first experiment, two buttons labelled with polar opposites of an adjective were positioned firstly one above the other and, secondly, side by side. In the second experiment, vertical and horizontal slider controls were used to represent a scale. The positioning or layout of the controls was specifically designed to support or contradict the image schema under test. For example, when testing the metaphorical extension of the UP-DOWN image schema, MORE IS UP, with a slider control, configuring a vertical slider control with the maximum value at the bottom would be considered contradictory to the image schema. Participants were asked to select the most appropriate button or move the slider to the most appropriate position in response to various phrases. The results revealed that, in general, response times were faster when the buttons or slider controls were configured to support the metaphorical extensions of the image schemas in vertical arrangements but did not appear to be affected in horizontal arrangements. However, as the experiments were restricted to a small number of image schemas, user interface controls and configurations, further work is required before the hypothesis that the use of image schemas as a tool for making design decisions leads to more intuitive designs can be claimed to be supported.

Investigating whether image schemas could be used as population stereotypes in tangible interactions, Hurtienne et al. (2009) carried out experiments asking participants to select the most appropriate object in response to an adjective describing an abstract property. The collection of objects the participants were provided with were of varying sizes, colours, weights, textures and temperature and were intended to represent various attribute image schemas, for example BIG-SMALL, LIGHT-DARK, ROUGH-SMOOTH, etc. Although the participants chose the expected object in a number of scenarios, the results also revealed a number of unanticipated mappings between the adjective and the

objects chosen, for example, the light green brick had both toxic and happy connotations.

These contradictory results led Hurtienne et al. to conclude that, although image schemas showed promise as a tool for user interface design, further work is necessary to establish the conditions and context within which they can be applied. This would seem a reasonable conclusion when taken into consideration with Eitan and Granot's (2006) and Eitan and Timmer's (2010) results, which revealed some unexpected mappings between musical parameters and spatial parameters.

In a contrasting study, Hurtienne (2011) and Hurtienne et al. (2008) investigated the use of image schemas as a "meta-language" for analysis and design. They undertook interviews, field observations and documentation reviews and were able to identify a number of image schemas reflecting the business processes, design and user interactions with an existing user interface for an invoice verification and posting system. They were then able to use this information to extrapolate a series of business and user requirements and use these to redesign the system. The process led them to conclude that such an approach encouraged them to focus on the essential user interface requirements. However, as Hurtienne (2011) acknowledges, further work is necessary to compare the benefits of this approach with other more established approaches such as task and use case analysis, personas, cognitive walkthroughs, etc.

3.2.3 Embodied Knowledge and Interaction Design

In addition to the studies applying image schema and conceptual metaphor theories to user interface design discussed above, work has also been undertaken to apply these theories to interaction design. Exploring whether physical gestures can be mapped to abstract concepts, Hurtienne et al. (2010) posit that if primary metaphors are indeed universal, they should be available to all users irrespective of cognitive ability and prior experience of technology. They carried out experiments asking two different age groups of participants to perform firstly, a suitable 2D gesture and secondly, a suitable 3D free-form gesture in response to a spatial dimension based on a source image schema (e.g. UP-DOWN) and a

phrase illustrating the target abstract concept (e.g. happiness). The combination of the spatial dimension and phrase represented a pre-selected primary metaphor (e.g. HAPPY IS UP-SAD IS DOWN). The results indicated that participants used gestures that were congruent with the pre-selected primary metaphor irrespective of their age or prior experience of technology, suggesting that gestures based on primary metaphors could provide a useful foundation for more inclusive interaction designs. Hurtienne et al.'s results are particularly interesting for this research as they provide further encouraging evidence of the potential benefits of using image schemas and conceptual metaphors as a technique for selecting appropriate interaction methods to promote intuitive designs.

Antle et al. (2008, 2009a, 2009b) investigated the advantages of incorporating embodied metaphors, conceptual metaphors that are extensions of image schemas specifically relating to embodied experiences and that operate at a sensory-motor level (Antle et al. 2009b), into interactive systems that enabled users to manipulate sound parameters such as pitch and volume by moving their bodies. Positing that interactions based on embodied metaphors would enhance both the ability of children to learn about abstract musical concepts (Antle et al. 2008) and result in more effective, efficient and enjoyable interactions (Antle et al. 2009b), they designed an interactive system that would enable users to manipulate sound parameters by using their bodies. In order to validate their hypotheses, they carried out experiments using two versions of the system; one version supported the embodied metaphors, while the other version used non-metaphor based mappings between bodily movement and sound parameters. Pairs of participants were asked to create sound sequences by varying specific sound parameters and then to explain each sound sequence. The results indicated that the version of the system that utilised embodied metaphors did appear to be easier to learn but, due to discrepancies between the participants' physical demonstrations and verbal explanations of the sound sequences, there was no clear evidence that this approach enhanced the ability of children to learn about abstract musical concepts (Antle et al. 2008). Furthermore, there did not

appear to be any significant difference in the perceived enjoyment in using one version of the system versus the other (Antle et al. 2009b). However, the results did highlight the importance of discoverability with respect to embodied metaphors as, unlike adults, children had difficulty identifying the correct mapping for pitch (Antle et al. 2009b).

Reflecting on their experiences of designing three separate systems based on embodied metaphors, Antle et al. (2009) note that designing such systems can prove challenging for a variety of reasons. In each case, the approach to design was similar; firstly relevant image schemas and embodied metaphors were identified, appropriate bodily movements to support the embodied metaphors were then explored and, finally, experiments were carried out to validate and refine the designs. Reviewing this approach and the difficulties and unexpected results they encountered, they list a series of key findings to guide the design of future systems:

“Most conceptual systems are understood through several embodied metaphors and often extend one or more primary schemata (e.g., up-down, in-out).

Users’ enactments of schemata and their metaphorical reasoning depend on both the content and context of the computation system.

Users’ tend to reason about an embedded interactive system using spatial schema to structure physical exploration and subsequent imaginative reasoning.

Designing an input space to confine input actions to a schema-specific set requires consideration of actions that are discoverable based on consideration of the order of directions which users’ tend to move; designing physical affordances and constraints in the space; providing task-related cues; and ensuring salient, immediate feedback.

Designing a system to support specific interpretations based on imaginative reasoning requires the use of the primary schema(s) in as many channels as possible (action affordances, multimodal feedback; layout; representational content) a stable error tolerant system; and salient feedback.

For users to deeply understand and reason about abstract concepts requires support for both reflection-in-action (tacit knowledge) and a stepping out or disengagement in order to reflect more deeply on experience and reflect consciously on interpretations.” (Antle et al. 2009)

Although these guidelines are particularly interesting as they highlight potential issues that could be encountered when employing such an approach, the interactive systems they were based on addressed simple tasks such as changing pitch and volume or reactions to social justice. It remains to be seen whether these guidelines are generally applicable to the design of systems employing an embodied approach to interaction or whether the inclusion of more complex and intertwined concepts and tasks result in further complications.

Although this present research does not attempt to answer these questions, we present an

alternative approach to the design process, providing musicians with a design goal and asking them to make design proposals for a system to carry out the more complex task of composing and modifying tonal harmonic progressions. We then explore how these proposals can be integrated into a consistent and useful prototype system. This approach is discussed further in chapters 8 and 9.

3.3 Summary

In this chapter we have reviewed the foundations upon which this research is based, namely that abstract concepts are understood in terms of prior sensory-motor experiences. We have discussed a number of applications of this theory of embodied understanding that are of particular relevance to this research, specifically music theory, user interface design and interaction design. In the following chapter we introduce and situate the questions this research aims to address and discuss the overarching methodology for this research.

4 Research Questions and Methodology

4.1 Overview

The purpose of this research is to investigate how conceptual metaphors relevant to musical concepts can be used to address the challenge of presenting complex domain abstractions within interaction designs using tonal harmony as an extended case study. Tonal harmony here may be seen as standing as a proxy for a range for complex musical tasks, and for complex tasks more generally. As part of this research a number of subsidiary questions were identified. These questions are discussed and situated within the context of the literature in the following sections.

4.2 Research Questions

4.2.1 How are Conceptual Metaphors Revealed in Conversations Between Musicians?

The first of our subsidiary research questions is “How are Conceptual Metaphors revealed in Conversations Between Musicians?” This may not appear to be the most obvious place to start on our wider research question, but it reflects the fact, as noted in the previous chapter, that while there are studies analysing image schemas found in *anecdotal utterances* and *written texts of music theory*, there has been little work to systematically analyse *conversation between musicians*. Consequently, there has been little or no information on the extent to which conceptual metaphors used in actual conversations between musicians are congruent with conceptual metaphors found in professionally edited and authored music theoretical monologues. We posit that conversations are a fruitful source of conceptual metaphors as the dynamic nature of a conversation and the interaction between the participants may better reflect musicians’ thought processes as they carry out tasks associated with music in comparison with the more precise and considered approach used in theoretical texts.

Existing studies exploring the application of image schema and conceptual metaphor theories to musical concepts include Zbikowski (1997, 1997-1998, 2009), Saslaw (1996,

1997-1998), Brower (1997-1998, 2000), Eitan and Granot (2006), Johnson (1997-1998), Johnson and Larson (2003), Larson (1997-1998), Larson and McAdams (2004), Larson and Vanhandel (2005) and Cox (2001). Generally, in these existing studies, the image schemas and conceptual metaphors explored were predominantly identified through analysis of various theory texts (e.g. Saslaw 1996, 1997-1998) or based on anecdotal examples of short linguistic phrases with little explanation of how, or from whom, these were elicited (e.g. Larson 1997-1998, Johnson and Larson 2003). Although theoretical texts are a vital source of descriptions of various musical concepts as understood by musical experts, as noted previously they may not necessarily reflect the language and conceptual metaphors used by musicians in conversation. In order to systematically explore conceptual metaphors used in actual conversations between musicians, a study was carried out involving three experienced musicians. The musicians were presented with an excerpt of a musical score and asked to discuss the harmonies, melodies and rhythms exhibited by the excerpt. The discussion between the musicians was then analysed to identify relevant conceptual metaphors. This study is presented in detail in chapter 5.

4.2.2 What Methods can be used to Elicit Conceptual Metaphors Relevant to Music?

The second of the subsidiary research questions considered in this thesis follows naturally from the first. Given that we wish to systematically study conceptual metaphors used in conversations between musicians, what methods can be used to elicit and analyse the relevant kinds of speech? As already noted, most previous studies have either focused on the analysis of music theory texts, or on anecdotal utterances. Analysis of theoretical texts aside, generally there has been limited information on how the linguistic phrases used to illustrate image schemas and conceptual metaphors were elicited.

However, away from music, information about elicitation techniques has been documented in a small number of applications of image schema and conceptual metaphor theories to user interface and interaction design (e.g. Hurtienne 2011, Hurtienne et al.

2008, Antle et al. 2009b, Antle et al. 2009, Antle et al. 2008, Baker et al. 2009). In these contexts, the elicitation of image schemas and conceptual metaphors typically takes a more task-oriented approach. For example, Hurtienne (2011) and Hurtienne et al. (2008) discuss the process of eliciting image schemas through context of use analysis, interviews, questions and user observations while Antle et al. (2009b, 2009, 2008) and Bakker et al. (2009) elicited embodied metaphors through movement studies, pilot studies and reviews of relevant literature. For our particular purposes, these precedents are of considerable interest, but their applicability is limited, since the studies in these domains are generally focused on simple tasks or restricted to simplified domain concepts. Thus, the associated elicitation methods are not necessarily well suited to deal with the potential complexity and open-ended nature of conversations between musicians about tonal harmony, as seen in the following two examples.

In the first example, Hurtienne (2011) and Hurtienne et al. (2008) designed a system for a relatively straightforward repetitive task with specific fixed decision points that would be worked through on a regular basis by the same user group who used the original system. In the second example, the systems designed by Antle et al. (2009b, 2009, 2008) were used to explore and manipulate concepts such as justice, pitch, volume etc and thus had minimal functionality. Of course, justice is potentially a complex concept but, as treated by the interfaces used in the study, complexity was minimal. By contrast, conversations between musicians about tonal harmony can involve substantial complexity. Therefore, an open question for this present research was to devise suitable methods for eliciting and analysing relevant conceptual metaphors from potentially complex conversations between musicians.

In order to explore this question, two studies were carried out with musicians of varying levels of experience. The first of these studies had two variants. In the initial variant of the first study, musicians were asked to use a set of words to describe short audio excerpts of music (both the words and audio excerpts were provided to the

musicians). In the second variant, musicians were asked to use a set of images as a basis for describing short audio excerpts of music (again, both the images and audio excerpts were provided to the musicians). The words and images were chosen to have the potential to be used to represent various image schemas. In the second study, musicians were asked to describe firstly, an excerpt of music they had brought with them and, secondly, a piece of music provided to them. The discussions between the musicians were then analysed to identify conceptual metaphors and provide a documented methodology for the identification process. These studies are discussed in more detail in chapter 6.

4.2.3 How can Conceptual Metaphors be used to Inform Interaction Designs for Music?

The third subsidiary research question was to explore ways in which Conceptual Metaphor Theory could be used to inform music interaction design, both in creating new designs and improving existing designs. The present research is not the first to apply image schema and conceptual and embodied metaphor theories to user interface and interaction design (e.g. Antle et al. 2009, Hurtienne 2011, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Hurtienne et al. 2010, Hurtienne et al. 2009, Treglown 1999), neither is it the first to apply these theories to sound or music-related parameters such as pitch, volume and tempo in user interface and interaction design (Antle et al. 2009b, Antle et al. 2008). However, to the best of our knowledge, no previous study has yet applied these concepts to interaction designs for complex musical structures such as tonal harmonic progressions.

In order to explore this subsidiary research question, two studies were carried out. In the first study, conceptual metaphors were used to evaluate two existing examples of music software with respect to whether or not the interaction designs supported the conceptual metaphors musicians used while discussing music. This study is discussed in detail in chapter 7.

In the second study, musicians were provided with a set of requirements and supporting materials for a wearable gesture-based system for creating tonal harmonic progressions and asked to design the system. In this case the requirements and supporting materials were based on conceptual metaphors. The discussions between the musicians were analysed along with the resulting design sketches in order to establish how they mapped conceptual metaphors to elements of the interaction design. This study is discussed further in chapter 8. Following on from this study, a prototype system was developed based on both the resulting designs produced by the musicians and on an analysis of their discussions while developing the designs. This prototype was then evaluated to determine whether or not users were able to create satisfactory tonal chord progressions using the system. The design and development of the prototype along with the evaluation study are discussed further in chapter 9.

4.3 Methodology

Detailed methodology for each study is presented in the relevant chapter; however, we include here for reference some brief information on the methodological principles that apply to all studies.

As the purpose of this research is to investigate how conceptual metaphors relevant to musical concepts can be used to address the challenge of presenting complex domain abstractions, it was necessary to ensure that conceptual metaphors were elicited from conversations between participants with a reasonable level of musical experience. Therefore, all of the studies undertaken as part of this research involved musically informed participants (excepting the evaluation study documented in chapter 7 which did not involve any participants).

As a large component of this research involved identifying conceptual metaphors relevant to music, and more specifically conceptual metaphors used by musicians in conversations, it was necessary to generate situations where conceptual metaphors could be revealed. Thus the studies discussed above (excepting the final study evaluating the

prototype system) were designed to engage groups of musicians in collaborative tasks, encouraging them to work together and discuss aspects of music or the task in hand between themselves. It was felt that collaboration, which would introduce the opportunity for participants to share and contrast ideas and opinions, would provide a more appropriate framework for eliciting relevant conceptual metaphors rather than other candidate techniques such as questionnaires, surveys, interviews or think aloud protocols. The former would restrict participants to predefined responses, while the latter can involve detachment or distraction. This also reflects our position that conversation may better reflect musicians' thought processes while they carry out tasks associated with tonal harmony than the more precise and considered descriptions provided in theoretical texts.

All studies that involved eliciting conceptual metaphors were audio recorded so that the discussions between the participants could be analysed to identify relevant image schemas and conceptual metaphors. The process for identifying image schemas and conceptual metaphors was based on linguistic examples given by other authors (e.g. Brower 2000, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Johnson 2005, Lakoff and Johnson 2003, Saslaw 1996, Zbikowski 1997). This process was refined as further studies were carried out and is discussed in detail in the relevant chapters.

4.4 Summary

In this chapter we have presented the questions this research aims to address with reference to relevant literature in the field. We have also presented a brief outline of the overarching methodological principles for this research. Detailed information on the various studies carried out to address the research questions is presented in the following five chapters.

5 How are Conceptual Metaphors Revealed in Conversations Between Musicians?

5.1 Overview

In this chapter, we address the first of the research questions identified in the previous chapter, namely how conceptual metaphors are revealed in conversations between musicians. To answer this question, a study was designed to identify the conceptual metaphors used by experienced musicians while they were analysing and discussing the structural properties of a short excerpt of music. By identifying conceptual metaphors in this manner, we hoped to ascertain whether the conceptual metaphors identified or implicitly referred to by other authors (e.g. Brower 2000, Eitan and Granot 2006, Johnson and Larson 2003, Saslaw 1996, 1997-1998, Zbikowski 1997, 1997-1998) were indeed used by musicians in conversation and to identify additional conceptual metaphors not previously documented. This study is discussed in the sections below.

5.2 Study Design

5.2.1 Participants

In order to ensure the participants in the study were able to fully understand and articulate the musical concepts they would be discussing during the study with enough detail, it was decided to recruit experienced and skilled musicians for the study. The three musicians chosen to take part were all educated to at least undergraduate level or equivalent in music and had experience of playing in groups of varying sizes. One of the musicians was a self employed professional musician and teacher. All the musicians knew each other.

5.2.2 Study Materials

An excerpt of a sacred motet, *Laudate Dominum omnes gentes* SV272, by Claudio Monteverdi arranged for voices, strings and basso continuo was chosen for the study. The excerpt chosen (the first twenty-two bars) juxtaposed alternating lively melodic movement with stately homophonic sections, which was hoped would generate ample opportunities for discussion among the participants. The participants were provided with a score of the

excerpt in standard music notation. Efforts were made to obscure the title, composer and lyrics in an attempt to avoid the participants making assumptions about the stylistic and harmonic structure of the excerpt based on what the title, composer and lyrics might suggest about the genre rather than the score itself.

5.2.3 Task

For the reasons discussed at length in the previous chapter, the participants were asked to work together on the task rather than work separately in order to maximise the opportunities for eliciting relevant conceptual metaphors. They were provided with the score of the excerpt and asked to work together to answer the following questions:

- Discuss the melodic movement in this excerpt.
- Discuss the harmonic progression in this excerpt.
- Discuss the interplay between the instrumental and vocal parts.
- Discuss how you feel about this piece of music.
- Identify an aspect of this excerpt that you find interesting and describe why.

The questions were designed to focus both on the structure of the excerpt in terms of the harmonies and melodies used and on interplay between the various parts, and also on the participants' emotional response to the excerpt. It was hoped that including not only detailed structural questions but also more general subjective questions would afford ample opportunities for relevant conceptual metaphors to be revealed.

5.3 Study Results

The study lasted approximately thirty minutes and was audio recorded. The discussion between the participants was transcribed and analysed to identify relevant image schemas and conceptual metaphors. The process of identifying relevant conceptual metaphors and the subsequent analysis of the results is discussed in the sections below.

5.3.1 Image Schema Identification

In order to identify relevant conceptual metaphors, it was necessary to firstly identify the source image schemas used. The image schemas used in the discussion were identified by

comparing the comments made by the participants with the examples provided by other authors (Hurtienne 2007, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Johnson 2005, Lakoff and Johnson 2003). Recall that image schemas by their nature are expected to be universal in application rather than domain specific. Systematic steps were taken to promote clarity in the identification of image schemas. Image schemas were identified only where both context and intention were very clear. For example, even though a phrase such as “all the way through” might imply the use of the SOURCE-PATH-GOAL image schema, this image schema was identified only when the participants used the prepositions “from” or “to”. In cases where the comments made by the participants were not relevant to the task in hand, the comments were disregarded and no image schema was identified. Despite such precautions, it is not always possible in general for interpretations of the dialogue to be unambiguous. In part, this is inherent in the task of identifying image schemas. However, experience gained in the present study created a useful foundation for reviewing and refining the process and rules for identifying image schemas in subsequent studies (see chapter 6). These refinements are discussed in more detail in the following chapter. However, the results discussed in this chapter reflect the initial methodology.

5.3.2 Conceptual Metaphor Identification

Conceptual metaphors were extrapolated from the identified image schemas based on examples provided by other authors (Hurtienne 2007, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Johnson 2005, Lakoff and Johnson 2003) taking into account the context that the image schema was used in. As with the identification of image schemas, systematic steps were taken to promote clarity in the identification of conceptual metaphors. For example, the frequency of each conceptual metaphor within the discussion was measured. Conceptual metaphors that were used only by one participant or only used a small number of times (less than four) throughout the course of the discussion were excluded. This helped to ensure that the conceptual

metaphors that remained reflected the participants' understanding of musical concepts in general. Table 5:1 below lists the conceptual metaphors identified in the discussion in descending order of frequency along with an example comment from the discussion to illustrate the context and use of the conceptual metaphor.

Table 5:1 - Table showing the most frequently used conceptual metaphors in the discussion along with an example comment to illustrate the use of the identified image schema and conceptual metaphor. The words used to identify the image schemas within the comments have been highlighted in bold italics. A version of this table was previously published in Wilkie et al. (2010).

Conceptual Metaphor	Frequency	Image Schema	Example Comment
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	17	SOURCE-PATH-GOAL	"...you've gone <i>from</i> A major <i>to</i> E major ..."
MUSICAL REPETITION	15	MATCHING	"...that delayed <i>echo</i> ..."
A PIECE OF MUSIC IS CONSTRUCTED FROM A NUMBER OF PARTS	14	PART-WHOLE	"...it's <i>got</i> vocal and instrumental <i>parts</i> ..."
A PIECE OF MUSIC IS AN OBJECT	14	OBJECT	" <i>It's</i> a nice piece."
MUSICAL STYLE IS A CONTINUUM	12	SCALE	"... <i>very</i> Italian, early Baroque ..."
A KEY/CHORD IS A CONTAINER [FOR NOTES]	10	CONTAINER	"...I'm <i>in</i> G major ..."
UNEXPECTED CHANGE IN MUSIC IS DIVERSION	9	DIVERSION	"...and then actually you've <i>got a complete mind shift</i> ."
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	8	SOURCE-PATH-GOAL	"...I wouldn't have said it suddenly <i>goes</i> homophonic ..."
A KEY/CHORD IS AN OBJECT	8	OBJECT	"This is the first big surprise isn't it, <i>this</i> A major chord..."
MUSICAL COMPLEXITY IS A CONTINUUM	7	SCALE	"Coz it's amazingly <i>simple</i> ..."
A PIECE OF MUSIC IS A CONTAINER	7	CONTAINER	"...and a big tutti coming <i>in</i> at bar thirteen"
HIGH PITCH IS UP/LOW PITCH IS DOWN	7	UP-DOWN	"...it goes <i>down</i> to E major. "
DIFFERENCE IN PITCH IS SIZE	5	BIG-SMALL	"There a <i>little</i> third..."
DIFFERENCE IN PITCH IS DISTANCE	5	NEAR-FAR	"Yeah the sort of <i>jumping about</i> the semiquavers, they're not...all next door..."
A REST IS AN OBJECT	5	OBJECT	" <i>That</i> rest! That rest!"

Conceptual Metaphor	Frequency	Image Schema	Example Comment
MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT	5	BLOCKAGE	[Referring to the rest] “Yeah I mean it's just kind of <i>hit a wall</i> a bit doesn't it.”
MUSICAL QUALITY IS A CONTINUUM	5	SCALE	“it obviously is [an] <i>incredibly well written</i> piece of music”
KEY/CHORDS ARE RELATED [TO THE TONIC]	4	LINKAGE	“...and when I see that chord I don't even need to, I don't need to analyze what it is in <i>relationship</i> to everything else...”

5.4 Discussion

As can be seen from table 5:1, a number of the conceptual metaphors that were identified were very high level and could be considered superficial, for example A REST IS AN OBJECT, A PIECE OF MUSIC IS AN OBJECT, MUSICAL REPETITION and MUSICAL QUALITY IS A CONTINUUM. However, some of the conceptual metaphors identified are associated with more complex musical concepts such as pitch and harmonic relationships. Table 5:2 below provides a summary of these conceptual metaphors and their associated musical concepts.

Table 5:2 - Table showing conceptual metaphors associated with complex musical concepts.

Musical Concept	Conceptual Metaphor
Chord structure	A KEY/CHORD IS A CONTAINER [FOR NOTES]
Harmonic progression	HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH
Harmonic relationships	KEY/CHORDS ARE RELATED [TO THE TONIC]
Musical structure	A PIECE OF MUSIC IS A CONTAINER
	A PIECE OF MUSIC IS CONSTRUCTED FROM A NUMBER OF PARTS
Pitch	DIFFERENCE IN PITCH IS DISTANCE
	DIFFERENCE IN PITCH IS SIZE
	HIGH PITCH IS UP/LOW PITCH IS DOWN

A number of the conceptual metaphors listed in table 5:2 above have also been previously identified or implicitly referred to by other authors, for example HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH (Brower 2000, Saslaw 1996), HIGH PITCH IS UP/LOW PITCH IS DOWN (Brower 2000, Eitan and Grant 2006, Eitan and Timmers 2010, Zbikowski 1997, 1997-1998), A KEY/CHORD IS A CONTAINER [FOR

NOTES] (Brower 2000, Saslaw 1996), KEY/CHORDS ARE RELATED TO THE TONIC (Brower 2000) and DIFFERENCE IN PITCH IS DISTANCE (Eitan and Grant 2006). This agreement between studies indicates the importance of these conceptual metaphors in our understanding of musical concepts and provides some validation for their identification.

Four conceptual metaphors specifically related to movement were identified in the analysis reflecting Johnson and Larson's (2003) and Eitan and Granot's (2006) hypothesis that music is understood in terms of motion:

- HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH
- A PIECE OF MUSIC IS MOVEMENT ALONG A PATH
- MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT
- UNEXPECTED CHANGE IN MUSIC IS DIVERSION

Furthermore, a number of the conceptual metaphors that were identified concur with Brower's (2000) hypothesis that the CONTAINER, CYCLE, VERTICALITY (UP-DOWN), BALANCE, CENTRE-PERIPHERY and SOURCE-PATH-GOAL image schemas are central to our understanding of musical concepts. These conceptual metaphors are listed in table 5:3 below. However, no conceptual metaphors associated with the CYCLE, BALANCE and CENTRE-PERIPHERY image schemas were identified in the analysis. It is unclear whether this is related to the analysis, the excerpt or the musicians' understanding of the excerpt.

Table 5:3 - Table showing the conceptual metaphors identified that relate to the image schemas highlighted by Brower (2000) as central to our understanding of musical concepts.

Conceptual Metaphor	Conceptual Metaphor Frequency	Source Image Schema
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	17	SOURCE-PATH-GOAL
A KEY/CHORD IS A CONTAINER [FOR NOTES]	10	CONTAINER
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	8	SOURCE-PATH-GOAL
A PIECE OF MUSIC IS A CONTAINER	7	CONTAINER

Conceptual Metaphor	Conceptual Metaphor Frequency	Source Image Schema
HIGH PITCH IS UP/LOW PITCH IS DOWN	7	UP-DOWN

Interestingly, the use of the two conceptual metaphors A PIECE OF MUSIC IS A CONTAINER and A KEY/CHORD IS A CONTAINER [FOR NOTES] implies that a piece of music (in standard musical score form at least) is understood in terms of nested containers. Certainly when we consider the layout of a standard musical score, a piece of music represented by the score itself does contain various musical parts, musical notes and bars while a musical key/chord is made up of a subset of notes in the chromatic scale.

5.5 Limitations

Despite the encouraging results from this study, a number of limitations were recognised. The opportunities to elicit conceptual metaphors were limited due to the shortness of the excerpt and the small number of participants. Furthermore, some potentially valid conceptual metaphors were discarded as they were used infrequently or by only one participant.

The format and genre of the excerpt itself may have also restricted the variety of conceptual metaphors used in the discussion. An excerpt of music in a different musical genre, for example classical or romantic, or even a different excerpt from the same genre, may have resulted in a different set of conceptual metaphors reflecting the differences in musical structure. Although arguably some conceptual metaphors such as HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH are likely to be prevalent across the majority of excerpts which utilise tonal harmonic progressions. An alternative representation of the excerpt, for example an audio or video file, may have resulted in a different set of conceptual metaphors as differences in the presentation format may have highlighted or obscured certain structural aspects or analysis processes. Certainly the visual appearance of a standard musical score does appear to highlight containment

relationships such as notes appearing within a bar, bars appearing within a part or the piece of music itself. This structure may not be so apparent in an audio representation.

5.6 Conclusions

Despite the limitations noted above, we have been able to validate a number of conceptual metaphors identified or implicitly referred to by other authors. This is particularly significant since the conceptual metaphors identified or implicitly referred to by other authors were often identified through analysis of theory texts, and thus may not have reflected the more spontaneous analysis processes used in discussions, or were not supported by a detailed explanation of the methodology used in the identification process. Therefore, this study and associated analysis goes some way to documenting a methodology for identifying conceptual metaphors used by musicians while analysing and discussing excerpts of music and provides some initial evidence of the conceptual metaphors used in such scenarios. This study also provides an example of a method for systematically guiding conversations between musicians in order to elicit relevant conceptual metaphors. Further methods are investigated and contrasted in the following chapter. As part of this investigation, the methodology for identifying image schemas and conceptual metaphors was further refined.

6 What Methods can be used to Elicit Conceptual Metaphors Relevant to Music?

6.1 Overview

In this chapter we consider the second of the research questions outlined in chapter 4, namely what methods can be used to elicit conceptual metaphors relevant to music. The previous study discussed in chapter 5 provided a preliminary methodology for eliciting relevant conceptual metaphors from experienced musicians as they discussed and analysed an excerpt of a previously unseen musical score. As noted in that chapter, this left open the question of whether the presentation of musical excerpts from a different musical genre or in an alternative format would result in differences in the conceptual metaphors revealed by the discussion. Furthermore, since all of the participants involved in that study were very experienced and skilled musicians, it remained unclear whether or not the conceptual metaphors that were identified in that study would be shared among musicians with more varied skill levels. With these two points in mind, this chapter presents two further studies that were carried out with musicians of varying skill levels. The two studies take contrasting approaches to facilitating the discussion among the musicians. The main purpose of the studies was to explore the benefits and drawbacks of the different methods of facilitating discussion and eliciting relevant conceptual metaphors. These studies are discussed in the sections below.

6.2 Study A – Eliciting Conceptual Metaphors Using Text and Images as Prompts

6.2.1 Study Design

In the first of the two studies discussed in this chapter, Study A, words and images based on image schemas were used to facilitate and encourage discussion about short excerpts of music. The details of this study are discussed in the sections below.

6.2.1.1 Participants

As in the previous study, in order to ensure relevant conceptual metaphors could be identified; it was necessary to recruit participants with an adequate level of musical experience. However, in contrast with the previous study where three highly skilled and experienced musicians were recruited to take part, the minimum level of experience required for Study A was a basic understanding of the principles of pitch, harmony and rhythm. Six participants were recruited to take part in the study. At the beginning of the study session, the participants were asked to fill out a short questionnaire to gather information about their musical experience. The results of the questionnaire revealed that all of the participants played at least one instrument and were comfortable reading standard music notation. A number of the participants had experience of playing in musical groups of one form or another and some had experience of teaching, conducting and composition and/or writing musical arrangements. All held a musical qualification although of varying levels from graded examination to a PhD in a music-based topic.

6.2.1.2 Study Materials

The first study discussed in chapter 5 involved only one excerpt of music provided in musical notation format. In order to address the question of whether or not excerpts of music in different genres would elicit a different corpus of conceptual metaphors, this study involved excerpts of audio recordings of music from varying musical genres including Baroque, folk, romantic and jazz. In addition, the excerpts used varied instrumentations including instrumental duet with accompaniment, jazz band and full orchestra. Excerpts from the following pieces of music were used:

- Hotteterre - Prelude Gravement from Sonata No 2 in D major
- Chopin - Prelude No 24 in D minor Opus 28
- Martyn - Over the Hill
- Bartok – 2nd movement Allegro from Music for Strings, Percussion and Celesta
- Lutoslawski - Symphony No 3

- Brahms – Variation V from Variations on a Theme by Haydn
- Martyn - May You Never (from Transatlantic Sessions Volume 1)
- Elgar – 4th movement Allegro Moderato, Allegro Ma Non Troppo from Cello Concerto in E minor Opus 85
- Monteverdi - Ave Maris Stella from Vespro della Beata Vergine 1610
- Davis - Freddie Freeloader

The excerpts varied from approximately fifteen to forty seconds in length and were taken at structurally interesting points within the piece. Excepting Monteverdi's Ave Maris Stella, which is principally a choral piece, excerpts from pieces that included vocal lines were taken at a point where no voice was present in an attempt to avoid the discussions being influenced by the lyrics. The decision was made to use an excerpt of Monteverdi's Ave Maris Stella that included vocal lines as it was felt that, since the lyrics were in Latin, they would be less likely to directly influence the discussion. It was hoped that such diverse excerpts would provide ample opportunities to elicit relevant conceptual metaphors from the discussions.

6.2.1.3 Tasks

This study was split into two separate tasks. For both tasks, in order to encourage conversation, the participants were split into pairs. Three study sessions were carried out, each with one pair of participants. As in the previous study discussed in chapter 5, it was hoped that asking the participants to work collaboratively would maximise the opportunities for eliciting relevant conceptual metaphors. The two tasks that formed this study are discussed in the sections below.

6.2.1.3.1 Task 1 – Using Words to Describe Musical Excerpts

In the first task, pairs of participants were provided with a set of words written on separate index cards (see table 6:1 below). The words chosen were associated with previously catalogued image schemas (Hurtienne and Blessing 2007). The words provided on the index cards were either drawn verbatim from the image schema or, in cases where it was

felt the intention of the word could be misunderstood or misapplied, a more accessible synonym was used. It was hoped that providing a list of words based on catalogued image schemas would encourage the participants to discuss the excerpts of music in terms of image schemas that were associated with directly relevant conceptual metaphors. The list of words used and their associated image schemas are shown in table 6:1 below. Image schemas that it was felt could be misconstrued, mistaken for another image schema or could lead to irrelevant discussion such as the COUNT-MASS image schema were avoided. It was also decided not to include words associated with the OBJECT, SCALE, CONTAINER and MATCHING image schemas for two reasons. Firstly, a number of conceptual metaphors associated with these image schemas had already been identified in the previous study discussed in chapter 5 and, secondly, it was felt that relationships between structural aspects of music and these image schemas were arguably obvious and potentially trivial. Although not all image schemas catalogued by Hurtienne and Blessing (2007) were included in the list, it was believed there was a wide and diverse enough selection to encourage sufficient relevant discussion.

Table 6:1 - Table showing the list of words used in the study with their associated image schemas.

Word	Associated Image Schema	Word	Associated Image Schema
JOURNEY	SOURCE-PATH-GOAL	SURPRISING	DIVERSION
STATIC	MOMENTUM (opposite)	PREDICTABLE	DIVERSION (opposite)
MOVING	MOMENTUM	ATTRACTING	ATTRACTION
FORCING	COMPULSION	REPELLING	COUNTERFORCE
BLOCKING	BLOCKAGE	ENCOURAGING	ENABLEMENT
CENTRAL	CENTRE-PERIPHERY	DISCOURAGING	RESISTANCE
PERIPHERAL	CENTRE-PERIPHERY	FULL	FULL-EMPTY
STABLE	BALANCE	EMPTY	FULL-EMPTY
UNSTABLE	BALANCE (opposite)	BIG	BIG-SMALL
HEAVY	HEAVY-LIGHT	SMALL	BIG-SMALL
LIGHT	HEAVY-LIGHT	UP	UP-DOWN
NEAR	NEAR-FAR	DOWN	UP-DOWN
FAR	NEAR-FAR		

The participants were played a selection of the excerpts chosen at random. After each excerpt was played, the participants were asked to describe the form and structure of the excerpt as if they were describing the excerpt to a third person who had not heard the excerpt before using the words provided on the index cards to assist. The participants were free to use as many of the provided words as they liked and were also free to write their own words on blank index cards to describe the excerpts. The participants were asked to discuss their choices with each other in order to facilitate discussion and encourage opportunities to identify relevant candidate conceptual metaphors.

6.2.1.3.2 Task 2 – Using Images to Describe Musical Excerpts

In the second task of the first study, the participants were provided with a set of images, each image printed on a separate piece of paper. As in the first task, each image was intended to represent a previously catalogued image schema (Hurtienne and Blessing 2007). The images were selected from the Microsoft Clip Art gallery and are shown with their associated image schemas in table 6:2 below. Excepting the COUNTERFORCE, ENABLEMENT and RESISTANCE image schemas where no suitable image could be found to represent the image schema, the same set of image schemas were used as those in task one.

Table 6:2 - Table showing the list of images used in the study with their associated image schemas.




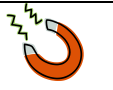


















Image	Associated Image Schema	Image	Associated Image Schema
	UP-DOWN		COMPULSION
	UP-DOWN		ATTRACTION
	NEAR-FAR		FULL-EMPTY
	NEAR-FAR		FULL-EMPTY
	DIVERSION		HEAVY-LIGHT

Image	Associated Image Schema	Image	Associated Image Schema
	DIVERSION (opposite)		HEAVY-LIGHT
	MOMENTUM (opposite)		CENTRE-PERIPHERY
	MOMENTUM		CENTRE-PERIPHERY
	BLOCKAGE		BALANCE
	BIG-SMALL		BALANCE (opposite)
	BIG-SMALL		SOURCE-PATH-GOAL

This task was structured in a similar way to the first task. The participants were played a selection of the excerpts chosen at random from the excerpts listed in section 6.2.1.2. Excerpts that had already been played to the participants during task one were excluded. As before, after each excerpt was played, the participants were asked to describe the form and structure of the excerpt as if they were describing the excerpt to a third person who had not heard the excerpt before using the images provided to assist. When choosing images to describe the excerpt, the participants were asked to consider the content of the images as well as what the image may represent to them in order to encourage the use as many of the images as possible. The participants were free to use as many of the provided images as they liked. The participants were asked to discuss their choices with each other in order to facilitate discussion and encourage opportunities to identify relevant conceptual metaphors.

6.2.2 Study Results

Each study session lasted no more than one hour and was audio recorded for subsequent analysis. Unfortunately, although the tasks generated some interesting discussions that included image-schematic references that could be extrapolated into conceptual metaphors,

the discussions included a number of literary descriptions of the excerpts rather than more detailed structural analyses as had been hoped. For example, in the first task, when discussing the excerpt of Bartok's Allegro from Music for Strings, Percussion and Celesta, one participant remarked:

"There's an implied aggression in it...I could use that as background music to a fight scene quite happily. Especially a standoff. That waiting for a sudden violent movement you know. It could work quite well."

Although the use of the terms "aggression" and "movement" in this remark could indicate the presence of a FORCE or MOMENTUM image schema, the remark contains no clear reference to any structural property of the excerpt.

In the second task in particular, the use of images appeared to encourage the participants to use images to either tell a story about the excerpt or use images to place the music within a particular context. For example, when discussing the excerpt of the Variation by Brahms, one participant, who decided to use her own image, stated:

"I might also go for something like...donkeys all running around...or lambs or something skipping and bouncing."

Discussing the duet sonata by Hotteterre, one participant selected the images of the telescope and scales commenting:

"I'm not sure why I'm thinking of the telescope. Again I'm probably thinking of the sort of courts where you have the astronomer royal. Maybe the scales as well...but in a similar justice kind of way. And the type of scale which looks quite old you know old fashioned or ornate."

Although the comments quoted above are arguably examples of novel metaphors, it was felt that the context within which they were used and the structural aspects of music they were referring to was not clear enough to enable relevant conceptual metaphors to be reliably identified. Taking into account the limited number of cases where relevant conceptual metaphors could be reliably identified, the decision was made to undertake no further analysis. As it was not possible to reliably identify candidate conceptual metaphors from the participants' conversations, the questions of whether or not musical genre or the skill and experience level of the participants had an effect on the breadth and depth of relevant conceptual metaphors revealed in the participants' conversations remains open. However, the results of the study revealed a number of key findings. Firstly, tasks should

be designed in such a way as to discourage the participants from discussing music in terms of a visual story as much as possible; in particular the impact of using visual images to describe music on the results of the task should be carefully considered. Secondly, tasks should clearly direct the participants' attention to the musical concepts that the study is designed to explore. In this study, asking the participants to describe the form and structure of the excerpt was arguably too general, and more specific direction towards harmonic progressions may have produced better results.

6.3 Study B – Eliciting Conceptual Metaphors Using Musical Notation as a Prompt

6.3.1 Study Design

In the next study, Study B, excerpts of musical scores (most of which were provided by the participants themselves) were used to facilitate and encourage discussion among the participants. The details of this study are discussed in the sections below.

6.3.1.1 Participants

As in Study A, in order to ensure that a large enough breadth of relevant conceptual metaphors at a suitable conceptual depth could be elicited, it was necessary to recruit participants with a reasonable level of musical experience. The minimum requirement to take part in the study was an understanding of the basics of harmony, pitch and rhythm as well the ability to play one instrument or sing and read standard music notation. Seven participants were recruited to take part in the study. As in study A, the participants were asked to complete a short questionnaire at the beginning of the study to gather information about their musical experience. The results of the questionnaire revealed that all of the participants played at least one instrument or sang regularly. Many of the participants held at least a secondary school or graded examination qualification in music while some of the participants had experience of conducting, composition, musical arrangement or teaching.

6.3.1.2 Study Materials

Study B was split into two tasks. For the first task, each participant was asked to bring a musical score and, in the case of instrumentalists, an instrument of their choice to the study session. A piano was provided for participants who preferred to use a keyboard instrument and singers were not required to bring an instrument. When choosing a musical score to bring to the study session, participants were asked to consider the following guidelines:

The piece of music need not be complete, i.e. you may bring along an excerpt of a larger piece of music. However, the excerpt should conform to these guidelines.

The piece of music/excerpt should be short, e.g. no more than approximately 32 bars.

The piece of music/excerpt need not have any specific instrumentation/voices or number of parts or be in any particular style, and can be as simple or complex as you prefer.

You should be familiar with the piece of music/excerpt and be comfortable discussing aspects of it such as the melodies, rhythm and harmonies with other participants. Please note that you may wish to play/sing extracts of the piece/excerpt on your chosen instrument/voice as part of the task.

It was hoped that asking participants to bring with them an excerpt of music with which they were familiar would encourage them to discuss the excerpt in greater detail than an unfamiliar excerpt.

For the second task in Study B, a musical score and audio recording of the recorder quartet *Report upon: "When Shall the Sun Shine?"* by Leenhouts was provided. This piece was chosen for two reasons. Firstly, it incorporates short excerpts and variations of well-known jazz pieces as well as use of vocal sounds and tapping noises; it was hoped that this would generate ample opportunities for discussion among the participants. Secondly, it was believed that the majority of the participants would be unlikely to know the piece thus affording the possibility of contrasting the results with the previous task (although as it turned out, one participant had heard the piece previously).

6.3.1.3 Tasks

Study B was split into two separate tasks. In order to encourage conversation between the participants and maximise the opportunities for eliciting relevant conceptual metaphors, the participants were split into three groups, two groups of two and one group of three. One study session was carried out with each group. The two tasks that formed this study are discussed in the sections below.

6.3.1.3.1 Task 1 of Study B

In the first task of Study B, the participants were asked to take it in turns to describe the excerpt of music they brought with them to the study session. The following questions were provided as a prompt; however the participants were free to discuss any aspects of the excerpt they wished:

- Why did you choose this piece of music?
- Can this piece of music be played on the instrument you have chosen? Can you explain why?
- Is there a particular aspect of this piece of music that particularly interests you? Can you explain why?
- Identify a melody within this piece of music and describe it.
- Identify a harmonic progression within this piece of music and describe it.
- Identify a rhythm within this piece of music and describe it.

Participants were encouraged to play or sing their chosen excerpt if they believed it would aid the description of the excerpt and if they were comfortable doing so. Once a participant had finished describing their chosen excerpt, the other participants were free to comment.

6.3.1.3.2 Task 2 of Study B

In the second task of Study B, the participants were provided with a score and audio recording of *Report upon: "When Shall the Sun Shine?"* by Leenhouts and asked to identify an aspect of the piece that interested them and describe it to the other participants. The participants were free to discuss any aspect of the piece, or a short excerpt of the piece, that they wished; however, the following questions were provided as a starting point for the discussions:

- Can this piece of music be played on the instrument you have chosen? Can you explain why?
- Is there a particular aspect of this piece of music that particularly interests you? Can you explain why?

- Identify a melody within this piece of music and describe it.
- Identify a harmonic progression within this piece of music and describe it.
- Identify a rhythm within this piece of music and describe it.

As in the first task, the participants were free to play or sing excerpts of the piece if they believed it would aid their description and they were comfortable doing so. Once a participant was finished describing their chosen aspect of the piece, the other participants were free to comment. It was hoped that providing both a score and an audio recording of the piece would enable the participants to build a fuller aural model of the piece and thus encourage them to discuss the piece more fully.

6.3.2 Study Results

Each study session lasted no more than one hour and was audio recorded. The audio recordings were transcribed and analysed to identify firstly, the image schemas used and, secondly, the associated conceptual metaphors used during the discussions. The process of identifying relevant conceptual metaphors and the subsequent analysis of the results is discussed in the sections below.

6.3.2.1 Image Schema Identification

Drawing on the experience of analysing the results of the first study discussed in chapter 5, a more rigorous approach to image schema and conceptual metaphor identification was developed. The approach took the form of the following steps:

1. All of the image schemas previously catalogued by Hurtienne and Blessing (2007) were listed.
2. The transcriptions of the audio recordings were analysed to identify relevant candidate image schemas used in the discussion.
3. Where a relevant image schema was identified from the transcriptions, the prepositions, verbs and adjectives, etc that indicated the presence of an image schema were listed against the corresponding entry in the image schema list in order to aid the identification of any further occurrences throughout the remainder of the analysis. The

list of image schemas and the associated words used to identify them within the transcription are shown in table 6:3 below. As in the first study discussed in chapter 5, examples of image schemas documented by other authors (e.g. Hurtienne 2007, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Johnson 2005, Lakoff and Johnson 2003) were used for reference.

4. Any decisions that were taken during the analysis regarding the potential identification of an image schema were listed, again with the intention of aiding the remainder of the analysis. The decisions are listed in table 6:4 below.

Table 6:3 - Table showing the words from the transcript used to identify each image schema. If no words were listed against an image schema, that image schema was not identified in the transcription.

Image Schema	Words Used for Identification
ATTRACTION	
BALANCE	
BIG-SMALL	Big, Small, Little, Few, Shorter, Longer
BLOCKAGE	Held
CENTRE-PERIPHERY	Middle, Point, Between, Halfway
COLLECTION	Together, Joined
COMPULSION	Push, Influenced, Swept, Lead, Drive, Follow (in the context of being led by), Bring, Take (in the context of being led by), Driving
CONTACT	Feel, Onto, Stick, Support, Striking, On
CONTAINER	In, Out, Into, Within
CONTENT	
COUNT-MASS	
COUNTERFORCE	Opposed
CYCLE	
DARK-BRIGHT	
DIVERSION	Change, Sudden (in the context of sudden change), Still (opposite)
ENABLEMENT	
FRONT-BACK	Back, Backwards, Forwards, Background
FULL-EMPTY	Full, Fill
HEAVY-LIGHT	Light
IN-OUT	
ITERATION	Again
LEFT-RIGHT	
LINKAGE	Linking
MATCHING	Repeat, Echo, Double, Same, Copy, Same, Contrast (opposite), Different (opposite), Repetition, Imitate, Unison

Image Schema	Words Used for Identification
MERGING	Mixed, Weave
MOMENTUM	Move, Moving, Stop (opposite), Stopping (opposite), Jump, Slow, Fast, Walking, Pause (opposite), Running, Stay (opposite), Flowing, Rest (opposite)
NEAR-FAR	Far, Closely
OBJECT	This, It
PART-WHOLE	Having, Got (in the context of belonging to), With, Keeps (in the context of belonging to), Get (in the context of will belong to), Has, Joining, Of (in the context of belonging to), Section, Part, Build, Take (in the context of will belong to), To it (in the context of belonging to), Your (in the context of belonging to), There (in the context of belonging to)
RESISTANCE	Against
RESTRAINT-REMOVAL	
ROTATION	
SCALE	Very, Really, Quite (in the context of more or less), Kind of (in the context of more or less like), Much, Loads, Slightly, Sort of (in the context of more or less like), Lots (in the context of more or less), Bit (in the context of more or less), Gradually, So (in the context of more or less), More
SELF-MOTION	
SOURCE-PATH-GOAL	From, To, Start, Finish, Going, Go, Goes, Gone, End, Along, Goes, After, Beginning, Before, Went, Way (in the context of all the way), Coming, Halfway, Through, Progression, Negotiate, Along, Previous, Final, First, Next
SPLITTING	
STRAIGHT	Straightforward
STRONG-WEAK	Strongly
SUBSTANCE	Substance
SURFACE	
UP-DOWN	Up, Down, High, Low, Falling, Underneath. Ascending, Over, Rising, Underlying
WARM-COLD	

Table 6:4 - Table showing the various rules for identifying image schemas that were catalogued during the analysis of the transcription.

Categorisation	Rule
Discarded Dialogue	Ignore all dialogue that is not relevant to music.
	Ignore all dialogue that references techniques for playing a specific instrument.
	Ignore all dialogue that references the construction of a specific instrument.
	Ignore all dialogue that refers to the piece of music in generic, literal terms such as 'lively', 'fun' or 'nice'.
	Ignore a phrase that is an immediate repeat within the same sentence.

Categorisation	Rule
	Ignore all dialogue that compares different arrangements of the same piece of music, particularly where the participant talks about aspects of the arrangements that are the same.
	Ignore all dialogue that references the piece of music within a larger collection of works.
	If the context is unclear or the relationship between concepts is unclear due to lack of dialogue or the use of very generic terms such as 'bits', any potential image schemas should be ignored.
Terminology	The term 'solo' is interchangeable with the term 'notes'.
	The term 'tune' is interchangeable with the term 'melody'.
Image Schema Identification	If the dialogue uses particular terminology for a specific pattern of notes, the PART-WHOLE image schema is identified on the basis that the excerpt must contain notes for the specific pattern of notes to be identified.
	References to specific instrumental parts are replaced with the term 'PART'.

Once all relevant image schemas had been identified using the rules listed in table

6:4, the frequency of each image schemas was counted. If an image schema was used multiple times within the same context and within the same comment made by a participant, only one instance of the image schema was counted. In this way, we were able to identify the number of distinct references to relevant image schemas within the transcription. Table 6:5 below shows the frequency of each image schema within each of the three study sessions.

Table 6:5 - Table showing the frequency of identified image schemas across the three study sessions.

Image Schema	Session 1	Session 2	Session 3	Total
ATTRACTION	0	0	0	0
BALANCE	0	0	0	0
BIG-SMALL	8	18	3	29
BLOCKAGE	0	2	0	2
CENTRE-PERIPHERY	7	8	4	19
COLLECTION	2	7	4	13
COMPULSION	7	5	2	14
CONTACT	12	10	2	24
CONTAINER	39	44	20	103
CONTENT	0	0	0	0
COUNT-MASS	0	0	0	0
COUNTERFORCE	0	1	0	1
CYCLE	0	0	0	0
DARK-BRIGHT	0	0	0	0

Image Schema	Session 1	Session 2	Session 3	Total
DIVERSION	6	1	1	8
ENABLEMENT	0	0	0	0
FRONT-BACK	14	7	5	26
FULL-EMPTY	2	0	0	2
HEAVY-LIGHT	0	1	0	1
IN-OUT	0	0	0	0
ITERATION	0	0	0	0
LEFT-RIGHT	0	0	0	0
LINKAGE	0	1	0	1
MATCHING	23	33	8	64
MERGING	1	0	0	1
MOMENTUM	22	10	9	41
NEAR-FAR	1	1	0	2
OBJECT	0	0	0	0
PART-WHOLE	25	81	18	124
RESISTANCE	1	0	0	1
RESTRAINT-REMOVAL	0	0	0	0
ROTATION	0	0	0	0
SCALE	26	9	2	37
SELF-MOTION	0	0	0	0
SOURCE-PATH-GOAL	52	68	29	149
SPLITTING	0	1	0	1
STRAIGHT	1	2	0	3
STRONG-WEAK	0	1	0	1
SUBSTANCE	0	0	0	0
SURFACE	0	0	0	0
UP-DOWN	11	19	9	39
WARM-COLD	0	0	0	0
Total Number of Image Schemas Identified	260	330	116	706

6.3.2.2 Conceptual Metaphor Identification

Relevant conceptual metaphors were then identified from the image schemas based on the context of the surrounding dialogue. Where a suitable conceptual metaphor could not be identified due to the context of the surrounding dialogue being unclear, or due to lack of detail or precision in the surrounding dialogue, a more generic high-level conceptual metaphor was identified. As an example of this, consider the following comment made by

a participant during task two while reviewing *Report upon: "When Shall the Sun Shine?"*

by Leenhouts:

*"It stays **in** G major **all the way** I think doesn't it. Up till there."*

The use of the preposition "**in**" and the phrase "**all the way**" indicates the use of the CONTAINER and SOURCE-PATH-GOAL image schemas respectively. However, the surrounding dialogue does not make it clear whether the participant is referring to the piece of music as a whole or a specific melody, part or section. On that basis, two high-level conceptual metaphors were identified; A KEY IS A CONTAINER FOR A PIECE OF MUSIC and A PIECE OF MUSIC IS MOVEMENT ALONG A PATH.

Table 6:6 below shows a list of the most frequently identified conceptual metaphors, their associated image schemas and a sample comment from the dialogue.

Table 6:6 - Table showing the most frequently used conceptual metaphors in each of the study sessions (columns S1, S2 and S3) along with an example comment to illustrate the use of the identified image schema and conceptual metaphor. The words used to identify the image schemas within the comments have been highlighted in bold italics.

Conceptual Metaphor	Image Schema	Sample Comment	S1	S2	S3	Total
A KEY IS A CONTAINER FOR MUSIC	CONTAINER	"And then it goes into minor halfway through"	0	0	10	10
A PART IS MOVEMENT	MOMENTUM	"...you've got sections with the walking bass "	7	2	1	10
A PIECE OF MUSIC IS A COLLECTION OF PARTS	COLLECTION	"Or the sudden fast triplets where they all come together as well."	2	6	3	11
A PIECE OF MUSIC IS MOVEMENT	MOMENTUM	"...then it moves into something else"	4	3	5	12
A SECTION IS MOVEMENT ALONG A PATH	SOURCE-PATH-GOAL	"And then you go off into another section"	8	4	0	12
MUSICAL STYLE IS A CONTINUUM	SCALE	"It's still a more classical than a jazz arrangement."	7	3	2	12
A KEY IS A CONTAINER FOR SECTIONS	CONTAINER	"...then they have sections of...of material you've heard before in a different key."	13	2	0	15
A PIECE OF MUSIC IS A CONTAINER FOR PARTS	CONTAINER	"...you have two parts and then the third part comes in ..."	2	13	1	16
A PART IS MOVEMENT ALONG A PATH	SOURCE-PATH-GOAL	"...the bass comes in with its final"	6	13	3	22

Conceptual Metaphor	Image Schema	Sample Comment	S1	S2	S3	Total
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	SOURCE-PATH-GOAL	"...you've got another section where you <i>go to</i> a minor key"	18	4	2	24
A PIECE OF MUSIC HAS A NUMBER OF SECTIONS	PART-WHOLE	"...then they <i>have sections of...</i> of material..."	5	20	1	26
A RETURN TO AN EARLIER THEME IS A CHANGE IN ORIENTATION	FRONT-BACK	"...you're swept <i>back</i> off and you're taken home"	14	7	5	26
A PIECE OF MUSIC HAS A NUMBER OF PARTS	PART-WHOLE	"...looked to see if it's closely aligned to the <i>voice part</i> "	3	21	7	31
HIGH PITCH IS UP/LOW PITCH IS DOWN	UP-DOWN	"...and then <i>they go high</i> "	11	14	8	33
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	SOURCE-PATH-GOAL	"...it has...a <i>middle, beginning and end</i> and the middle..."	9	31	17	57
MUSICAL REPETITION	MATCHING	"...the melody, the words are <i>the same...</i> "	23	33	8	64

6.3.3 Discussion

Across the three study sessions, over seven hundred instances of image schemas and associated conceptual metaphors were identified. Some of the most frequently identified conceptual metaphors were associated with the SOURCE-PATH-GOAL image schema, which was itself the most frequently identified image schema (see table 6:6 above). This reflects previous claims (Johnson and Larson 2003, Eitan and Grant 2006) that music is understood in terms of motion and supports similar findings in the first study discussed in chapter 5 where the SOURCE-PATH-GOAL image schema also represented a significant number of the total image schemas identified. As can be seen from table 6:6 above, a number of the most frequently identified conceptual metaphors were associated with musical structure and movement. However, many of those are arguably high-level, for example A PIECE OF MUSIC IS MOVEMENT, and are not specifically related to the harmonic, rhythmic or melodic structure of the excerpts. Since the participants were

provided with a set of questions as prompts that referenced harmonic, melodic and rhythmic structure, it was felt that, unlike study A, the tasks themselves provided sufficient guidance on the level and type of detail that should be covered. Therefore, two possible reasons for the identification of a large number of high-level conceptual metaphors are proposed:

- The revised approach to identifying conceptual metaphors as detailed in sections 6.3.2.1 and 6.3.2.2 in this chapter (as contrasted with the process discussed in chapter 5) recommends the selection of a high-level conceptual metaphor if the context or dialogue is unclear leading to fewer specific conceptual metaphors being identified.
- The participants were not comfortable discussing the structural aspects of the excerpts in detail or did not have the relevant musical skills, experience or time to undertake more detailed analysis.

Table 6:7 below shows a summary of the most frequently identified conceptual metaphors and their associated musical concepts.

Table 6:7 - Table showing the most frequently identified conceptual metaphors and their associated musical concepts.

Musical Concept	Conceptual Metaphor
Chord/harmonic structure	A KEY IS A CONTAINER FOR MUSIC
	A KEY IS A CONTAINER FOR SECTIONS
Harmonic progression	HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH
Musical structure	A PIECE OF MUSIC HAS A NUMBER OF PARTS
	A PIECE OF MUSIC HAS A NUMBER OF SECTIONS
	A PIECE OF MUSIC IS A COLLECTION OF PARTS
	A PIECE OF MUSIC IS A CONTAINER FOR PARTS
	MUSICAL REPETITION
Movement	A PART IS MOVEMENT
	A PART IS MOVEMENT ALONG A PATH
	A PIECE OF MUSIC IS MOVEMENT
	A PIECE OF MUSIC IS MOVEMENT ALONG A PATH
	A SECTION IS MOVEMENT ALONG A PATH
Pitch	HIGH PITCH IS UP/LOW PITCH IS DOWN
Stylistic qualities	MUSICAL STYLE IS A CONTINUUM

The first study discussed in chapter 5 did not reveal any examples of conceptual metaphors associated with the CYCLE, BALANCE and CENTRE-PERIPHERY image

schemas which were identified by Brower (2000) as central to our understanding of musical concepts along with the SOURCE-PATH-GOAL, CONTAINER AND VERTICALITY (UP-DOWN) image schemas. The results of this study partially support this finding as no examples of the use of the CYCLE and BALANCE image schemas were identified; however a relatively small number of examples of the use of the CENTRE-PERIPHERY image schema were identified (19 out of the total 706). A brief review of the transcription from the first study discussed in chapter 5 using the terms used to identify the CENTRE-PERIPHERY image schema in this study (see table 6:3 above) only revealed one or two possible examples of the use of this image schema reflecting the similar small percentage of instances identified in this study. The lack of references to the BALANCE, CYCLE and CENTRE-PERIPHERY image schemas across the two studies could be attributed to a number of different reasons:

1. These image schemas are applied at a much more granular level that is not readily expressed during discussions.
2. The process of identifying image schemas requires further refinement in order to better identify more subtle usage of image schemas rather than relying on a set of prepositions, verbs and adjectives.
3. The tasks did not lend themselves to discussing the musical excerpts in terms of these image schemas.
4. The participants did not conceptualise the structural properties of the musical excerpts in terms of these image schemas. Since the two studies involved musicians with varying levels of experience including highly skilled experts, it is unlikely that this is a reflection on all the participants' musical experience or background.
5. The structural properties of the musical excerpts did not lend them to being discussed in terms of these image schemas. However, since a number of excerpts in various instrumentations and genres were used across the two studies, it would seem unlikely that none of the excerpts exhibited material that could be described in these terms.

Further studies would be required to explore these possibilities; however, such studies are outside of the scope of this research.

6.4 Comparison of Methods

Across the two studies discussed in this chapter, a number of approaches to eliciting conceptual metaphors were explored:

1. Using text prompts to describe excerpts of music in audio format.
2. Using image prompts to describe excerpts of music in audio format.
3. Structured discussion of excerpts of music chosen in advance by the participants in score format with optional demonstrations.
4. Structured discussion of a piece of music in both score and audio format with optional demonstrations.

The fourth of these approaches was similar to that used in the first study discussed in chapter 5; however, in that study, a short excerpt of a full piece of music was used and the excerpt was provided in musical score format only.

Of the four approaches itemised above and discussed in this chapter, the third and fourth approaches involving structured discussion were the most successful for eliciting relevant conceptual metaphors. The first two approaches were less successful for this purpose as the use of word and image prompts often appeared to encourage the participants to build a story around the musical excerpts leading to ambiguity around the identification of relevant conceptual metaphors. These findings indicate that the method of encouraging discussion that is most likely to lead to the identification of relevant conceptual metaphors is to use musical scores and questions tailored specifically to encourage the participants to analyse and discuss aspects of music in greater detail.

The design of the studies discussed in this chapter also attempted to address three of the limitations identified in the first study discussed in chapter 5; namely the number and experience of the participants, the number and variety of musical excerpts used and the

representation format used for musical excerpts. We will treat each of these three issues in turn.

Firstly, both of the studies discussed in this chapter were carried out with a larger number of participants (although some participants did take part in both studies) who had varying levels of musical skill and experience. However, all of the participants still had at least a good understanding of music and experience of playing instruments and/or singing. The results of all three studies do suggest that a more detailed discussion of the structural aspects of music took place when all of the participants were very skilled and experienced musicians in contrast with scenarios where the participants had more varied levels of experience.

Secondly, both studies discussed in this chapter involved a number of different excerpts of music in varying genres. Although this made for a more interesting discussion for the participants, it is unclear if this had a material affect on the number of relevant conceptual metaphors identified. Certainly different excerpts and styles of music will exhibit different structural qualities that may impact on the set of relevant conceptual metaphors elicited. However, it is possible that including more excerpts resulted in less detailed structural analysis as less time was spent discussing any one excerpt. Further studies would be required to explore this aspect of study design.

Thirdly and finally, the first study discussed in this chapter, study A, used musical excerpts presented as audio files, while the second study, study B, used musical scores, optional demonstrations and one audio file. Although the introduction of audio files and optional demonstrations provided additional examples of eliciting conceptual metaphors through different representation formats, the study that was most successful for eliciting relevant conceptual metaphors used a combination of audio files, optional demonstrations and musical scores. The first study only made use of audio files, although the use of word and image prompts and lack of clarity in the study instructions also appear to have had a significant impact on the success of the study for the purposes of eliciting relevant

conceptual metaphors. Again, this indicates that the inclusion of musical scores in the study materials is likely to provide greater opportunities to elicit relevant conceptual metaphors.

6.4.1 Limitations

The studies discussed in this chapter attempted to address a number of the limitations identified in the study discussed in chapter 5; namely the number and experience of the participants, the number and variety of musical excerpts and the representation formats of the musical excerpts. Despite this, the representation formats used in the two studies discussed in this chapter, audio files and musical scores with optional demonstrations, were still relatively limited. It remains to be seen whether videos of performances or alternative score formats such as guitar tablature, figured bass or lead sheets would indirectly influence the course of the participants' discussions.

6.5 Conclusions

Despite the problems encountered with the design and analysis of the results of study A, we have been able to explore the effect of a number of different parameters. Firstly, we have explored whether the materials and prompts provided to the participants has an effect on the number of relevant conceptual metaphors elicited. The results suggest that the most successful method of encouraging discussion with musically well-educated participants, and the method most likely to lead to the identification of relevant conceptual metaphors, is to use musical scores and questions that are designed to direct the participants to analyse and discuss specific structural aspects of the musical excerpts.

We have also made some preliminary investigations (in part by comparison with the results of the first study discussed in chapter 5) as to whether the level of musical skills and experience of the participants has a material affect on the number of relevant conceptual metaphors elicited. As the process for identifying relevant image schemas and conceptual metaphors differed across the studies, it is not possible to directly compare the number of relevant conceptual metaphors identified. However, a review of the transcriptions does

appear to suggest that the first study discussed in chapter 5, which involved three very skilled and experienced musicians, did produce a more thorough analysis of the musical excerpt under consideration. However, since study B discussed in this chapter used a greater number of musical excerpts, meaning less time was spent analysing each musical excerpt, this result is not conclusive. Nonetheless, we posit that involving as many highly skilled and experienced musicians as possible and restricting the number of musical excerpts is likely to produce a more thorough analysis.

In addition to exploring the study designs and methods that can be used to elicit relevant conceptual metaphors, we have also outlined a methodology for identifying conceptual metaphors associated with musical concepts through the documentation of our analysis process. This methodology is a refined version of the initial methodology presented in chapter 5.

The next step in this research is to explore how conceptual metaphors can be used to inform music interaction designs. The following two chapters cover the use of conceptual metaphors to evaluate existing music interaction designs and the use of conceptual metaphors to facilitate design discussions with domain experts respectively.

7 How can Conceptual Metaphors be used to Evaluate Music Interaction Designs?

7.1 Overview

The third step in this research was to investigate how conceptual metaphors can be used to inform music interaction designs. Two approaches were taken. The first approach, and the one which is discussed in this chapter, was to explore whether conceptual metaphors could be used to evaluate existing music interaction designs. The second approach, discussed in the next chapter, involved the use of conceptual metaphors as priming material for design discussions.

There are a small number of documented examples of using image schemas and conceptual metaphors as a technique for evaluating existing user interface and interaction designs (Hurtienne et al. 2008, Hurtienne 2011, Treglown 1999, Rohrer 1995). Rohrer (1995) analyses the differences between the desktop and trashcan metaphors and users' understanding of the real world equivalents within the context of Image Schema Theory, although his analysis is more of a discussion rather than a systematic evaluation. Treglown (1999) discussed the image schemas and conceptual metaphors exposed by the interaction designs of three short case studies (one of which was a brief discussion of Rohrer's (1995) earlier study) but relied upon his own assessment of what would constitute the user's understanding of the concepts afforded by the user interfaces. Hurtienne (2011) and Hurtienne et al. (2008) identified the image schemas present in the user interface of an existing system for invoice verification and posting system as part of a context-of-use analysis. The analysis compared the identified image schemas with the users' understanding of the process as evidenced through comments made by the users themselves during observation sessions. The results were used to identify the user requirements for a redesigned version of the system and highlight shortcomings in the existing design. Useful though all these studies are, the interaction designs under consideration dealt with relatively straightforward concepts and tasks when contrasted with

the complexities involved in composing music and tonal harmonic progressions in particular. To that end, a study was designed to investigate whether a systematic evaluation of existing music interaction designs using domain-specific conceptual metaphors would reveal useful information of two kinds; firstly, to illuminate the decisions made by the interaction designers and, secondly, to provide an indication of any potential improvements that could be made to the designs in order to better support users' understanding of the domain concepts. The study made use of the corpus of conceptual metaphors identified in the first study as detailed in chapter 5. This study is discussed in the sections below.

7.2 Study Design

7.2.1 Evaluation Materials

In this study, two examples of music software, Harmony Space (Holland 1994) and GarageBand (Apple Inc. 2009) were chosen for the evaluation process. These two applications are contrasted in table 7:1 below and detailed in the sections below.

Table 7:1 - Table contrasting Harmony Space (Holland 1994) and GarageBand (Apple Inc. 2009). A version of this table was previously published in Wilkie et al. (2010).

Aspect	Harmony Space	GarageBand
Primary User Group	Primarily aimed at novices but no barrier to expert use.	Primarily aimed at novice and intermediate users but no barrier to expert use.
Primary Tasks Supported	Harmonic analysis of existing musical artifacts and generation of new harmonic progressions.	Music generation and production, learning to play songs and musical instruments.
User Interface	Custom design based on theories of harmonic perception. Musical relationships are organised spatially. Time is represented by time, augmented by traces.	Similar layout to other music production software such as Logic Pro (Apple Inc. 2012). Musical content is organised by time. Time is represented by horizontal distance.

7.2.1.1 Harmony Space

Harmony Space (Holland 1994) was designed to teach musical novices the principles of tonal harmony and harmonic progressions. The design of the system was based on theories of harmonic perception proposed by Balzano (1980) and Longuet-Higgins (1962) and

exploits spatial metaphors, visual grouping, proximity judgements and straight-line movement. Various versions of Harmony Space are available using different interaction models (e.g. the whole-body interaction version discussed in Holland et al. (2009)); however, the desktop version shown in the annotated screenshot in figure 7:1 below was chosen for the purposes of this study.

Harmony Space displays the twelve notes of the chromatic scale in a repeating two-dimensional grid pattern. The notes in the grid will be highlighted in white forming a 'key window' if they are available in the current key context, or black if they are not available in the current key context. In the case of figure 7:1 below, the notes of the G major scale are highlighted in white. If the selected key context changes, the highlighted notes will be updated accordingly. In a basic configuration, selecting a note within the key window will play a three-note chord with the selected note as the root note, allowing the user to play and interact with basic harmonic progressions and identify visual paths of harmonic movement as the chords are played. In addition to this functionality, Harmony Space also provides various tools for recording, tracing and modifying chords along with a selection of secondary displays to provide supporting information such as the piano roll display shown in figure 7:1 below.

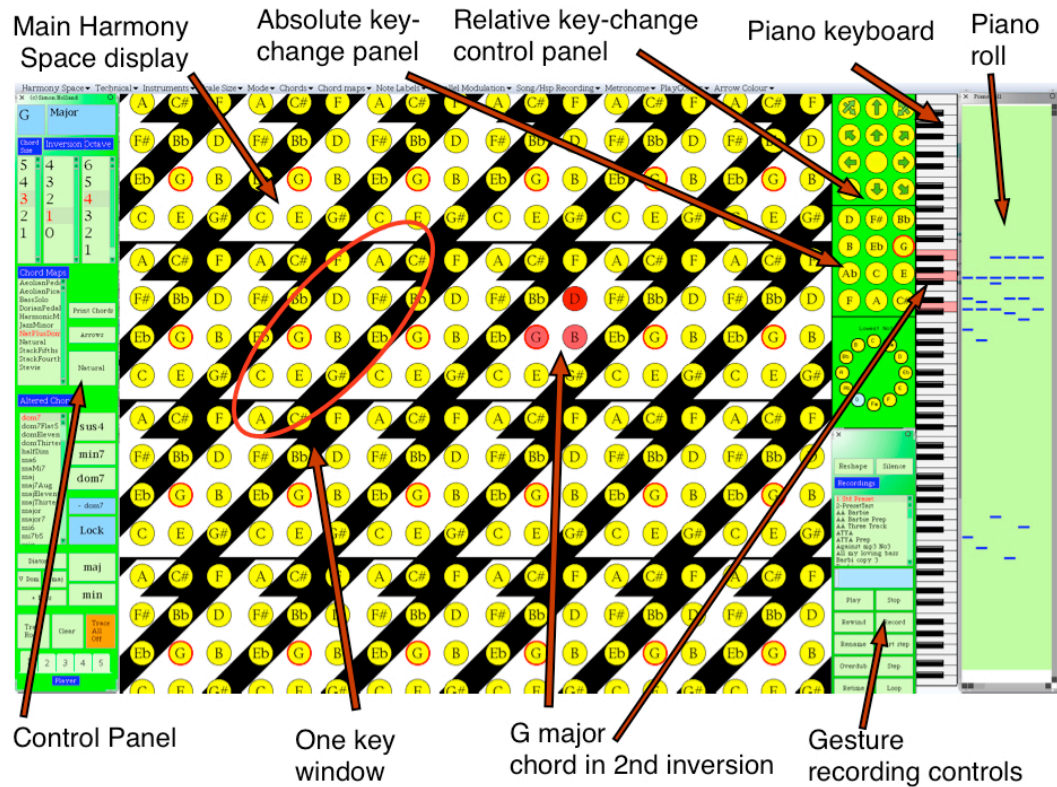


Figure 7:1 - Screenshot of the desktop version of Harmony Space, previously published in Wilkie et al. (2010, 2009a, 2009b).

7.2.1.2 GarageBand

GarageBand (Apple Inc. 2009) is a commercially available application allowing users to record and mix audio or MIDI tracks, play along with a pre-set band or learn an instrument such as the piano or guitar. The design of the recording and mixing functionality draws on well-established digital audio workstation designs such as Logic Pro (Apple Inc. 2012) and Pro Tools (Avid Technology Inc. 2013). GarageBand is included as part of Apple's standard iLife package supplied with new Apple computers and is thus relatively widely available⁵.

7.2.2 Evaluation Method

The two interaction designs were assessed separately using the same systematic approach. This approach drew on the conceptual metaphors identified in the first study (as itemised in chapter 5⁶). Each assessment considered the degree to which each conceptual metaphor

⁵ The evaluation was carried out using an earlier version of GarageBand. Further information on the current version of GarageBand including screenshots is available on Apple's website, <http://www.apple.com/uk/mac/garageband/>.

⁶ See table 5:1 in chapter 5.

was supported or contradicted by various aspects of the design. Aspects assessed included the layout, behaviour and configuration of the controls. This enabled both of the interaction designs to be assessed overall on the extent to which it supported, partially supported or contradicted each conceptual metaphor.

7.3 Study Results

The results of the evaluation for each interaction design are discussed in the sections below.

7.3.1 Harmony Space

The evaluation revealed that Harmony Space supported many but not all of the conceptual metaphors. The detailed results of the evaluation are provided in table 7:2 below.

Table 7:2 - Table showing the results of the evaluation of Harmony Space.

Conceptual Metaphor	Supported?	Comments
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Yes	Harmony Space is specifically designed to support learning harmony through exploiting users' understanding of movement from one chord to the next. This is supported in the software by moving the key window to change key and the chord trace history.
MUSICAL REPETITION	Partial	Harmonic repetition can be easily identified as a repeating path, however repetition in other aspects of music will not be identifiable.
A PIECE OF MUSIC IS CONSTRUCTED FROM A NUMBER OF PARTS	Partial	This is partially supported by highlighting the notes in the chord and using colour to indicate octave height, although it would not be clear which notes form which part.
A PIECE OF MUSIC IS AN OBJECT	Yes	A piece of music is displayed in a window, which could be understood as an object.
MUSICAL STYLE IS A CONTINUUM	No	The concept of style is based on training and pattern recognition and is not supported in this software.
A KEY/CHORD IS A CONTAINER [FOR NOTES]	Yes	This is supported by the key window and highlighting the notes within the selected chord.
UNEXPECTED CHANGE IN MUSIC IS DIVERSION	Partial	In terms of harmony, this may be seen as an unexpected change in direction. However, changes in other aspects of music are not supported.
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	Yes	By moving between the different chords and keys in the piece, a piece of music can easily be seen as movement along a path.

Conceptual Metaphor	Supported?	Comments
A KEY/CHORD IS AN OBJECT	Yes	This is supported by the key window and clicking on a note to sound a chord.
MUSICAL COMPLEXITY IS A CONTINUUM	No	Evaluating complexity is based on experience and is not supported in this software.
A PIECE OF MUSIC IS A CONTAINER	Yes	As a piece of music is played within one window, the window could correspond to the piece being a container that contains a number of chords.
HIGH PITCH IS UP/LOW PITCH IS DOWN	Partial	This is not supported in the grid but is supported by the piano roll display. However, this concept is not necessary for understanding the basics of harmony.
DIFFERENCE IN PITCH IS SIZE	Partial	This is not supported in the grid but is supported by the piano roll display. However, this concept is not necessary for understanding the basics of harmony.
DIFFERENCE IN PITCH IS DISTANCE	Partial	This is not supported in the grid but is supported by the piano roll display. However, this concept is not necessary for understanding the basics of harmony.
A REST IS AN OBJECT	No	The concept of a rest or musical silence is not supported in Harmony Space. However, this is not necessary for understanding the basics of harmony.
MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT	No	The concept of a rest or musical silence is not supported in Harmony Space. However, this is not necessary for understanding the basics of harmony.
MUSICAL QUALITY IS A CONTINUUM	No	This concept of quality is based on musical training and personal preference.
KEY/CHORDS ARE RELATED [TO THE TONIC]	Yes	The key window allows users to see which chords will appear in a particular key suggesting a relationship between the tonic chord and the other chords within that key context.

As expected, Harmony Space has greater support for conceptual metaphors associated with harmony and movement than those associated with other aspects of music. For example, the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH, which was the most frequently identified conceptual metaphor in the first dialogue study (see chapter 5), is well supported through the movement of the key window indicating modulation to a different key. This conceptual metaphor is also supported by the chord trace functionality shown in figure 7:2 below. This feature was a recent addition to Harmony Space, and was prompted by an earlier trial of this evaluation

technique that highlighted that such an addition would enhance support for this conceptual metaphor. The designer had previously identified the need for such a trace function, but had considered it a low priority. The designer felt that that the evaluation made a convincing case that the importance of this feature had been seriously underestimated and implemented it immediately after the results of the evaluation were provided to him.

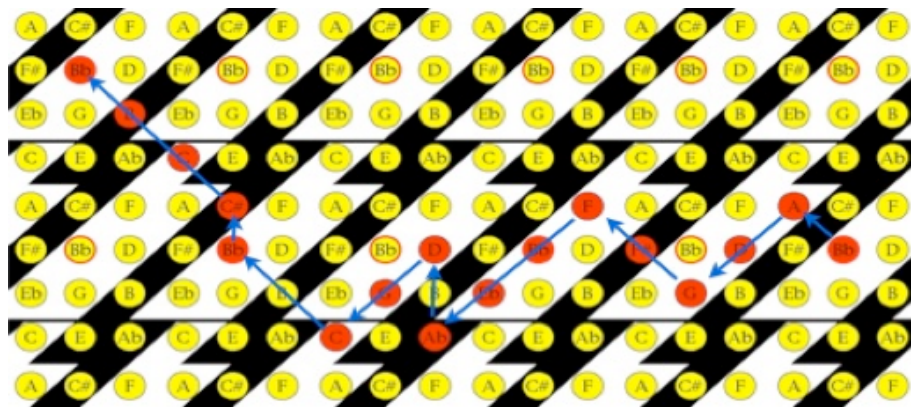


Figure 7:2 - Screenshot illustrating the chord trace functionality in Harmony Space. The notes highlighted in red indicate the chords that were played while the arrows highlight the path taken by the chords. Previously published in Wilkie et al. (2009b).

Support for conceptual metaphors associated with other aspects of music, for example pitch and rhythm, are less well defined within Harmony Space. Conceptual metaphors associated with pitch such as HIGH PITCH IS UP/LOW PITCH IS DOWN, DIFFERENCE IN PITCH IS SIZE and DIFFERENCE IN PITCH IS DISTANCE are not supported in the main grid but are supported in the piano roll display. However, a variant of the HIGH PITCH IS UP/LOW PITCH IS DOWN conceptual metaphor, HIGH PITCH IS BRIGHT/LOW PITCH IS DARK, is supported in the grid display as colour is used to indicate octave height. By contrast, Harmony Space has little or no support for the conceptual metaphors A REST IS AN OBJECT and MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT. These omissions are not surprising when we consider that Harmony Space was designed to aid users in learning the principles of harmonic progressions and relationships but does restrict the user's ability to explore other aspects of musical structure such as rhythm and voice leading.

7.3.2 GarageBand

Like Harmony Space, GarageBand supports some but not all of the conceptual metaphors identified in the first study discussed in chapter 5. However, the pattern of conceptual metaphors supported is strikingly different from that of Harmony Space, as summarised in table 7:3 below.

Table 7:3 - Table showing the results of the evaluation of GarageBand.

Conceptual Metaphor	Supported?	Comments
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	No	Garage Band is not designed to assist the user in identifying harmonic relationships so this information is not provided. However, by using the location line it is clear which parts are playing together forming a chord. When using MIDI tracks it is possible to see the different notes (MIDI blocks) changing as the chords change; however the support for this is very weak.
MUSICAL REPETITION	Partial	When MIDI information is displayed, it is possible to identify repeating patterns of musical movement visually. This is not so obvious for audio information.
A PIECE OF MUSIC IS CONSTRUCTED FROM A NUMBER OF PARTS	Yes	A part is represented as a track displaying either audio or MIDI information.
A PIECE OF MUSIC IS AN OBJECT	Yes	A piece of music is displayed in a window, which could be understood as an object.
MUSICAL STYLE IS A CONTINUUM	Partial	The concept of style is based on training and pattern recognition and musical style is not immediately obvious in the UI presentation. However, GarageBand does allow the user to create a new piece of music in a specific genre.
A KEY/CHORD IS A CONTAINER [FOR NOTES]	Yes	It is possible to change the key the piece of music is playing in. Doing this automatically transposes the note information.
UNEXPECTED CHANGE IN MUSIC IS DIVERSION	Partial	Changes in certain musical parameters such as repetitions, silences or rhythm can be identified relatively easily through the MIDI tracks as there will be corresponding changes in the MIDI information blocks. Other parameters such as harmonic progressions are harder to identify.
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	Yes	This is supported through the location line and track scrolling.
A KEY/CHORD IS AN OBJECT	No	It is possible to extrapolate which tracks play together at certain points in the piece; however this is not obvious.

Conceptual Metaphor	Supported?	Comments
MUSICAL COMPLEXITY IS A CONTINUUM	No	Evaluating complexity is based on experience and is not supported in this software.
A PIECE OF MUSIC IS A CONTAINER	Yes	Each piece is opened in a new window with all of the tracks displayed in the central area.
HIGH PITCH IS UP/LOW PITCH IS DOWN	Yes	When displaying MIDI tracks, the vertical position of a block corresponds to the pitch. This is assisted by the piano roll layout where a piano keyboard is positioned vertically to indicate the actual pitch of a note.
DIFFERENCE IN PITCH IS SIZE	Yes	Pitch is represented on the vertical axis therefore difference in pitch can be seen as the vertical difference between two notes.
DIFFERENCE IN PITCH IS DISTANCE	Yes	Pitch is represented on the vertical axis therefore difference in pitch can be seen as the vertical difference between two notes.
A REST IS AN OBJECT	Partial	Musical rest or silence is indicated by a lack of MIDI information blocks so could be seen to be an entity in its own right, though certainly not to the same degree as the identification of a rest in staff notation.
MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT	Partial	Musical silence is indicated by a lack of note blocks so could be seen as a blockage to the movement of a particular part. However, since the playback involves dynamic scrolling of the piece of music, the music appears to continue moving even during moments of complete silence, which is contradictory to this conceptual metaphor.
MUSICAL QUALITY IS A CONTINUUM	No	This concept of quality is based on musical training and personal preference.
KEY/CHORDS ARE RELATED [TO THE TONIC]	No	GarageBand does not include the facility to identify harmonic relationships.

As might be expected, given that the two applications are designed for different tasks, the conceptual metaphors supported by GarageBand are different from those supported by Harmony Space. For example, GarageBand provides better support for the conceptual metaphor A PIECE OF MUSIC IS CONSTRUCTED FROM A NUMBER OF PARTS as each part is shown as a separate task in the main application window. In contrast with Harmony Space, GarageBand provides greater support for the conceptual metaphors associated with pitch HIGH PITCH IS UP/LOW PITCH IS DOWN, DIFFERENCE IN PITCH IS SIZE and DIFFERENCE IN PITCH IS DISTANCE. Like

Harmony Space, GarageBand supports these conceptual metaphors via a piano roll display but also provides some limited additional support via the display of MIDI note information within tracks as the vertical position of a MIDI note block gives a basic indication of pitch.

The conceptual metaphor A PIECE OF MUSIC IS MOVEMENT ALONG A PATH is well supported in GarageBand by the horizontal scrolling of the tracks during playback. However, this functionality strongly contradicts the conceptual metaphor MUSICAL SILENCE IS A BLOCKAGE TO MOVEMENT as even if a track is currently silent, the track still scrolls horizontally. GarageBand also provides support for the conceptual metaphor A KEY IS A CONTAINER FOR NOTES as changing the key of a piece of music automatically updates the MIDI note information within the MIDI tracks implying a change in pitch. However, the variant of this conceptual metaphor, A CHORD IS A CONTAINER FOR NOTES, is not obviously supported. Furthermore, there is no explicit support for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH but this is not surprising given that GarageBand is not designed for tasks associated with harmonic analysis.

7.4 Discussion

In this study we have explored how a corpus of conceptual metaphors elicited from domain experts can be used to evaluate existing interaction designs. In general, the evaluation identified no serious flaws in the designs of either application. However, the evaluation process was able to identify various categories of issues with the existing designs along with some opportunities for improvement. These included the following:

- Reduced support for a specific conceptual metaphor associated with a task that the interaction design was intended to support. An example of this is the recently added chord trace functionality in Harmony Space to enhance support for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH after an early trial evaluation using the process described here.

- Areas of tension and trade-offs in the design of the user interface where support for one task was enhanced at the expense of another. An example of this is the lack of explicit support for the conceptual metaphor **HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH** in GarageBand.

The evaluation process itself was lengthy and required knowledge of Conceptual Metaphor Theory, consequently this approach could be impractical in situations where time and resources are restricted. However, exploring the use of image schemas as meta-language for user interface design, Hurtienne (2011) concluded that user interface designers were able to understand and apply Image Schema Theory as part of the analysis and design phases of a user interface design cycle. This indicates that, with some initial training, designers should be able to utilise Conceptual Metaphor Theory for the purposes of evaluation as well. Certainly the results detailed here suggest that applying such an approach could prove useful when considering how well the primary tasks of a interaction design are supported by the layout, behaviour and configuration of the controls.

7.5 Limitations

As the evaluation study used the corpus of conceptual metaphors identified during the first study discussed in chapter 5, this study effectively shares the same set of limitations. With respect to the evaluation process itself, only the layout, behaviour and configuration of the controls was considered. The evaluation process did not take into account any other potentially influencing factors such as the terminology used, the layout of the user interface and details of the steps required to complete a task. As such features will have an impact on the user's mental model of the system, the evaluation technique discussed in this chapter would be improved by considering these features.

It is unclear whether an evaluation using other established techniques such as cognitive walkthroughs or user observations would produce similar results. Further studies beyond the current scope would be required to contrast a conceptual metaphor-based evaluation technique with other evaluation techniques.

7.6 Conclusions

In this study we have explored how a corpus of conceptual metaphors elicited from domain experts can be used to evaluate existing interaction designs. We evaluated two examples of existing music software, Harmony Space (Holland 1994) and GarageBand (Apple Inc. 2009), and were able to identify trade-offs and tension in the designs and opportunities for improvement. To the best of our knowledge, this is the first study to use conceptual metaphors as a technique for evaluating existing interaction designs for music or any other domain with comparable complexity. Although the evaluation process proved lengthy, arguably, it is not unreasonable to posit that, once the technique is practiced, the time required may be comparable with other expert heuristic evaluations such as Nielsen (1995).

In the following chapter we explore how conceptual metaphors may be used to inform design decisions.

8 How can Conceptual Metaphors be used to Inform Design Decisions?

8.1 Overview

The final stage in this research was to explore the extent to which conceptual metaphors relevant to music could be used to inform design decisions. This component of the research is addressed in two parts. The first part, covered in this chapter, investigates the use of conceptual metaphors as priming material for design discussions. The second part utilises the results of those design discussions to develop a prototype system for creating tonal harmonic progressions. The second part is the subject of the following chapter.

Despite a number of documented examples of applications of image schema, conceptual metaphor and embodied theories to user interface and interaction design (Antle 2009, Antle et al. 2009, Antle et al. 2009a, 2009b, Antle et al. 2008, Bakker et al. 2009, Hurtienne 2011, Hurtienne and Blessing 2007, Hurtienne and Israel 2007, Hurtienne et al. 2008, Hurtienne et al. 2009, Hurtienne et al. 2010, Rohrer 1995, Treglown 1999), to the best of our knowledge, no previous studies have investigated the use of conceptual metaphors as a tool to inform design proposals made by domain experts actively engaged in design discussions. To that end, a study was designed to investigate the extent to which conceptual metaphors could be used to inform design proposals made by domain experts through mapping conceptual metaphors to elements of an interaction design. This study is discussed in the sections below.

8.2 Study Design

8.2.1 Participants

As this research is particularly concerned with the design of interactions for tonal harmony, it was decided that the study would focus on the design of a tool for creating and modifying tonal harmonic progressions. In order to ensure the participants in the study were able to fully understand and articulate the musical concepts they would be discussing during the study in enough detail, it was decided to recruit participants with knowledge of

harmonic theory and/or experience of composition or musical arrangement. Four participants were chosen to take part, all of whom matched these criteria.

8.2.2 Study Materials

As knowledge of Conceptual Metaphor Theory was *not* a prerequisite to take part in the study, it was necessary to provide participants with a framework to enable them to map conceptual metaphors to elements of an interaction design in the absence of any understanding of the principles of Conceptual Metaphor Theory. Therefore, a set of supporting materials was designed to provide the participants with such a framework. The set of supporting materials was based on a selection of conceptual metaphors associated with harmonic progression. The selected conceptual metaphors were restricted to those associated with tonal harmonic progression for two reasons:

- Conceptual metaphors associated with harmony are relatively well documented in the literature (Brower 2000, Saslaw 1996) and a number of these were validated by the results of our previous studies documented in chapters 5 and 6.
- Restricting the set of conceptual metaphors to those associated with harmony would allow the participants to focus on designing a self-contained system to create tonal harmonic progressions without being unduly distracted by other musical concepts.

The supporting materials for the study were developed as follows. Firstly, a design goal was chosen to enable the participants to focus their design efforts. The design goal was a jumpsuit that would enable the wearer to create and modify tonal harmonic progressions (further details were left open to the participants, as described below). The choice of design goal was motivated as follows:

- A jumpsuit would provide multiple possibilities for interactions including gestures and incorporating elements of clothing such as pockets and buttons.
- It was believed that as conceptual metaphors are based on prior sensory-motor experiences, participants would find it easier to map conceptual metaphors to physical gestures rather than user interface controls such as sliders and text boxes.

- A jumpsuit design based on physical gestures would be less likely to be influenced by other desktop-based music systems of which the participants may already have experience.

Once a design goal had been chosen, the next step was to identify suitable conceptual metaphors that the participants could use to map to elements of the jumpsuit design. Four conceptual metaphors were chosen to open up the design space:

- HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH
- HARMONIC PROGRESSION IS MOVEMENT
- A PIECE OF MUSIC IS A CONTAINER FOR CHORDS
- A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY

The conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH was chosen as it was the most frequently identified conceptual metaphor in the first study (discussed in chapter 5) and appeared regularly in the third study (discussed in chapter 6). In contrast to the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH, the more generic HARMONIC PROGRESSION IS MOVEMENT conceptual metaphor was chosen to explore whether participants would find it easier to associate simpler movements with musical concepts rather than more complex movements involving paths. This conceptual metaphor appeared in the results of the third study (discussed in chapter 6), albeit infrequently. The final two conceptual metaphors A PIECE OF MUSIC IS A CONTAINER FOR CHORDS and A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY did not appear in the results of the previous studies discussed in earlier chapters. Of these, A PIECE OF MUSIC IS A CONTAINER FOR CHORDS was chosen as a generic conceptual metaphor that could represent the concept of containment in relation to harmonic progression. A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY was chosen based on Brower's (2000) hypothesis that BALANCE was one of the image schemas central to the understanding of tonal music. Although no conceptual metaphors based on the BALANCE

image schema had been identified in the previous studies discussed in earlier chapters, it was decided to include a conceptual metaphor based on this image schema in order to explore whether or not the participants would associate this conceptual metaphor with musical concepts and map it to elements of the jumpsuit design. It was hoped that restricting the number of conceptual metaphors to four would discourage the participants from creating overly complex designs with minimal references to each conceptual metaphor.

The next step in preparation for the study was to create a framework that would make it possible for participants to map conceptual metaphors to elements of the jumpsuit design without requiring any knowledge of Conceptual Metaphor Theory. To achieve this, the selected conceptual metaphors were used to develop a set of supporting materials for the study. The materials were as follows:

1. Two task scenarios describing the use of the jumpsuit.
2. A list of the musical actions the jumpsuit should support in order to satisfy the task scenarios.
3. A list of suggested functionality the jumpsuit could have.
4. Sketch representations of the four conceptual metaphors.
5. A sample list of suggested ways in which the conceptual metaphors could be mapped to the jumpsuit functionality.

Each of the five study materials was provided to the participants on separate sheets of paper. Although the materials were intended to provide the participants with a framework for mapping conceptual metaphors to elements of the jumpsuit design, the participants were free to use or reject the materials as they wished. The development of these study materials is discussed in the section below.

8.2.2.1 Development of the Study Materials

Two task scenarios were developed based around creating and modifying harmonic progressions. To encourage the participants to focus on keeping the designs simple and to

avoid overly complex functionality for supporting intricate musical concepts, the personas involved in both task scenarios had limited musical knowledge. The task scenarios were as follows:

Task scenario 1

“Bob loves listening to music, especially film music, and enjoys going to local folk rock gigs. He doesn't play an instrument himself although he took piano lessons many years ago at school but didn't enjoy the scale exercises his teacher asked him to do so he stopped after a few months.

Last week while watching a film, he became particularly engrossed in an excerpt from the accompanying music. He downloaded a copy of the soundtrack to listen to but would love to be able to explore the chord sequence from the excerpt that particularly interested him, and perhaps try modifying the chords to see if that changes his emotional response to them. Bob puts on the Magic Music Jumpsuit, uploads a copy of the soundtrack and starts exploring the chords...”

What is the Magic Music Jumpsuit and how is it used explore and modify chord sequences⁷?

Task scenario 2

“Jane is a keen amateur film maker and enjoys spending her spare time filming her two cats playing and creating short movie clips. She would love to be able to add some atmospheric soundtracks to her films but she has no experience of composing music herself. She received a Magic Music Jumpsuit for her birthday and decides to try using it to create some short chord sequences...”

What is the Magic Music Jumpsuit and how is it used to generate chord sequences?

Analysis of the task scenarios led to the next step in the development of study materials.

Based on the information in the two task scenarios, a list was made of all of the basic musical actions that the jumpsuit would need to support in order to satisfy the requirements of the two task scenarios:

- Playing a chord sequence
- Stopping playback
- Adding a chord into an existing chord sequence
- Removing a chord from an existing chord sequence
- Changing tonal centre
- Changing tempo
- Repetition

To provide the participants with some suggestions of what types of interactions a user may be able to have with the jumpsuit, an illustrative list of sample functionality was provided for the jumpsuit:

⁷ The term “chord sequence” is interchangeable with the term “harmonic progression” for the purposes of this thesis.

- The jumpsuit can detect if you place objects in the pockets.
- The jumpsuit can detect if you take objects out of the pockets.
- The jumpsuit can detect if the buttons are pressed.
- The jumpsuit can detect if you move your arms up and down, left and right and forward and back.
- The jumpsuit can detect if you move your feet.
- The jumpsuit can detect if you move your arms or feet faster or slower.
- The jumpsuit can detect if your centre of gravity changes.

To assist the participants with understanding the selected conceptual metaphors, a rudimentary sketch was developed for each of the four conceptual metaphors. The associated conceptual metaphor was provided to the participants along with the sketch in order that they could better interpret the sketch (no reference to the term ‘conceptual metaphor’ was included in the sketches). The sketches are shown in figures 8:1 to 8:4 below.



Figure 8:1 - Sketch representation of HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH

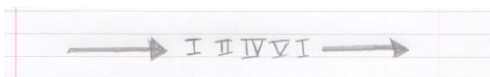


Figure 8:2 - Sketch representation of HARMONIC PROGRESSION IS MOVEMENT

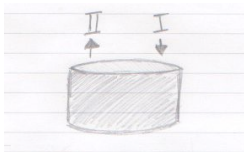


Figure 8:3 Sketch representation of A PIECE OF MUSIC IS A CONTAINER FOR CHORDS

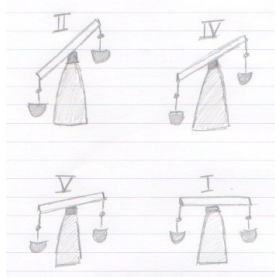


Figure 8:4 - Sketch representation of A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY

To assist the participants with associating the conceptual metaphors to the functionality supported by the jumpsuit, a list of suggested mappings were provided:

- Containment could be expressed by putting an object in a pocket.
- Movement could be expressed by moving your arms or feet.
- Movement along a path could be expressed by walking or tracing a path with your hands.
- Changing your centre of gravity could be expressed by placing more weight on one foot or leaning to one side.

Although the materials contained casual references to conceptual metaphors, none of the materials provided to the participants specifically mentioned the term conceptual metaphor or discussed aspects of Conceptual Metaphor Theory. The intention was that the set of materials described above would provide the participants with a framework upon which to base their design proposals and enable them to map conceptual metaphors to elements of the jumpsuit design without requiring any knowledge of Conceptual Metaphor Theory.

8.2.3 Task

In order to encourage conversation, the participants were split into pairs. Two study sessions were carried out, each with one pair of participants. As in the studies discussed in previous chapters, the intention was to maximise the opportunities for discussion by asking the participants to work collaboratively.

Each pair of participants was asked to work together to produce a sketch for the jumpsuit using the materials provided. The participants were free to use or reject as much

of the suggested jumpsuit functionality and mappings between conceptual metaphors and functionality as they wished.

8.3 Study Results

The two study sessions lasted approximately one hour each and were audio recorded.

Three design sketches (see figures 8:5 and 8:6 below) were produced during the study sessions. In general, each study session took a different approach to the design of the jumpsuit. The participants in the first study session produced a design that incorporated walking and various arm gestures to control the functionality of the jumpsuit. The participants in the second study session produced two design sketches. The first of these was reminiscent of the sketch produced in the first study session, incorporating arm and leg movements. However, due to time constraints, the participants decided to focus their attention on the second design which incorporated tangible objects and pockets on the jumpsuit

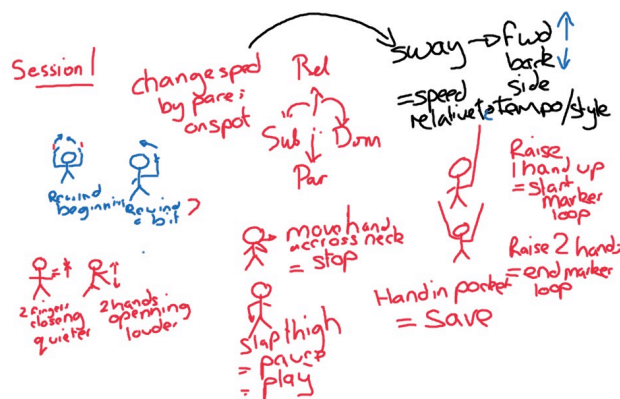


Figure 8:5 - Design sketch produced by participants in study session one.



Figure 8:6 - Design sketches produced by participants in study session two.

The audio recordings of the discussions between the participants were transcribed and analysed. This enabled the identification of the mappings the participants made between conceptual metaphors and the elements of the jumpsuit design. The sketches produced in the study sessions were analysed in conjunction with the audio transcriptions. The process of identifying the mappings and analysing the sketches is discussed in the section below.

8.3.1 Conceptual Metaphor Mapping Identification

The transcription of the audio recordings of the study sessions were analysed to identify the mappings between conceptual metaphors and elements of the jumpsuit design as follows:

1. The comments made by the participants were analysed in order to identify the jumpsuit functionality or gesture that was being discussed, for example walking, changing direction, arm movement, etc.
2. For each reference to jumpsuit functionality or gesture, the musical action that was being discussed in association with the functionality or gesture was identified, for example chord identification, tempo, playing music, etc.
3. The comments made by the participants were analysed to identify the image schemas used.
4. The mappings between functionality and image schemas were identified, for example movement along a path being expressed through walking, changing direction expressed through turning, etc.
5. The conceptual metaphors used in the discussions were then identified.
6. The design sketches were analysed to ascertain whether or not the conceptual metaphor and associated mapping appeared in the final design. This was achieved by analysing the diagrams and annotations incorporated within the design sketches and comparing these with the list of conceptual metaphor mappings. If the diagram or annotation

appeared to refer to a conceptual metaphor mapping, the conceptual metaphor mapping was considered to have appeared in the design.

Some excerpts from the transcriptions of the study sessions are included below to illustrate the analysis process.

Study Session One

“Maybe I'm just thinking about it coz what we're talking about is this idea of *pacing through the music*.”

Functionality/Gesture: Walking

Musical action: Playing music

Mapping: Movement along a path expressed by walking

Image schema: SOURCE-PATH-GOAL

Conceptual metaphor: A PIECE OF MUSIC IS MOVEMENT ALONG A PATH

Element of design sketch:



“Just by putting your *hand in your pocket* it saves it.”

Functionality/Gesture: Put hand in pocket

Musical action: Save music

Mapping: Containment expressed by putting hand in pocket

Image schema: CONTAINER

Conceptual metaphor: SAVING MUSIC IS CONTAINMENT

Element of design sketch:

Hand in pocket
= Save

Study Session Two

“...the exact mapping I haven't decided but if we have *one for standing on the left leg, five on the right leg and maybe four even*.”

Functionality/Gesture: Stand on one leg

Musical action: Chord sequence

Mapping: Movement along a path expressed by balancing on legs

Image schema: BALANCE

Conceptual metaphor: HARMONIC PROGRESSION IS CHANGE IN BALANCE

Element of design sketch:

balance on legs
start jumps

“I...I would like...my gut feeling now is that we could have erm...say *seven marbles which would represent A B C D E F*.”

Functionality/Gesture: Tangible object

Musical action: Musical notes

Mapping: A concept is expressed by a physical object

Image schema: OBJECT

Conceptual metaphor: A NOTE IS AN OBJECT

Element of design sketch:



Tables 8:1 and 8:2 below detail the results of the analysis of the transcriptions and design sketches produced for each study session.

Table 8:1 - Table showing the conceptual metaphor mappings identified in study session one. Highlighted rows indicate a conceptual metaphor that was included as part of the study materials.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	In Design?
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	23	YES
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	FRONT-BACK	6	YES
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	6	YES
A CHANGE IN DIRECTION IS A CHANGE IN CHORD	Change direction	LEFT-RIGHT	4	YES
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	SOURCE-PATH-GOAL	4	YES
A CHANGE IN DIRECTION IS A CHANGE IN CHORD	Change direction	FRONT-BACK	3	YES
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	LEFT-RIGHT	3	YES
STARTING A SECTION IS CONTACT	Tapping	CONTACT	3	NO
A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD	Move both hands	FRONT-BACK	2	NO
A CHANGE IN SPEED OF MOVEMENT IS A CHANGE IN TEMPO	Walking	MOMENTUM	2	YES
A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE	Sway forwards and backwards	FRONT-BACK	2	YES

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	In Design?
OF GRAVITY				
SAVING MUSIC IS CONTAINMENT	Put object in pocket	CONTAINER	2	NO
STARTING A SECTION IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	2	NO
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	UP-DOWN	1	NO
A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD	Move one hand	FRONT-BACK	1	NO
A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD	Move both thumbs	FRONT-BACK	1	YES
A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY	Change centre of gravity	BALANCE	1	YES
A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY	Sway left and right	LEFT-RIGHT	1	NO
A CHANGE IN TIMBRE IS A CHANGE IN THE CENTRE OF GRAVITY	Sway left and right	LEFT-RIGHT	1	YES
A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY	Change centre of gravity	BALANCE	1	NO
HARMONIC PROGRESSION IS CONTACT	Tapping	CONTACT	1	NO
SAVING A CHORD IS CONTAINMENT	Put hand in pocket	CONTAINMENT	1	NO
SAVING MUSIC IS CONTAINMENT	Put hand in pocket	CONTAINER	1	YES
STARTING A SECTION IS CONTACT	Clapping	CONTACT	1	NO
STARTING A SECTION IS UP	Raise one hand	UP-DOWN	1	YES
STOPPING A SECTION IS CONTACT	Clapping	CONTACT	1	NO
STOPPING A SECTION IS CONTACT	Tapping	CONTACT	1	NO
STOPPING A SECTION IS	Walking	SOURCE-PATH-	1	NO

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	In Design?
MOVEMENT ALONG A PATH		GOAL		
STOPPING A SECTION IS UP	Raise both hands	UP-DOWN	1	YES
STOPPING MUSIC IS CONTACT	Slap leg	CONTACT	1	YES
STOPPING MUSIC IS MOVEMENT	Move one hand	MOMENTUM	1	YES
VOLUME IS DISTANCE	Move fingers	UP-DOWN	1	YES

Table 8:2 - Table showing the conceptual metaphor mappings identified in study session two. Highlighted rows indicate a conceptual metaphor that was included as part of the study materials.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	In Design?
A CHORD IS AN OBJECT	Tangible object	OBJECT	9	NO
SAVING MUSIC IS AN OBJECT	Tangible object	OBJECT	8	YES
A HARMONIC PROGRESSION IS AN OBJECT	Tangible object	OBJECT	7	NO
HARMONIC PROGRESSION IS MOVEMENT	General body movement	MOMENTUM	5	YES
A NOTE IS AN OBJECT	Tangible object	OBJECT	4	YES
AN INVERSION IS AN OBJECT	Tangible object	OBJECT	3	NO
HARMONIC PROGRESSION IS CHANGE IN BALANCE	Balance on both legs	BALANCE	3	YES
A CHANGE IN SPEED OF CONTACT IS A CHANGE IN TEMPO	Clapping	CONTACT	2	YES
HARMONIC PROGRESSION IS CHANGE IN BALANCE	Stand on one leg	BALANCE	2	YES
A CHANGE IN CHORD IS A CHANGE IN CENTRE OF GRAVITY	Change centre of gravity	BALANCE	2	YES
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	2	NO

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	In Design?
SAVING MUSIC IS A CONTAINER	Pocket	CONTAINER	2	NO
A CHANGE IN BALANCE IS A CHANGE IN TEMPO	Change centre of gravity	BALANCE	1	NO
A CHORD IS A WHOLE WHOSE PARTS ARE NOTES	Tangible object	PART-WHOLE	1	YES
A CHORD IS A CONTAINER FOR NOTES	Pocket	CONTAINER	1	YES
A PIECE OF MUSIC IS NOT MOVEMENT	Less movement	(NOT) MOMENTUM	1	NO
HARMONIC PROGRESSION IS CONTACT	Clapping	CONTACT	1	NO
HARMONIC PROGRESSION IS MOVEMENT	Move body	MOMENTUM	1	YES
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Moving arms	SOURCE-PATH-GOAL	1	YES
MODIFICATION IS AN OBJECT	Tangible object	OBJECT	1	NO
SAVING MUSIC IS MOVEMENT	Movement	MOMENTUM	1	NO
STARTING MUSIC IS CONTACT	Hit object	CONTACT	1	YES

Image schemas and conceptual metaphors were identified based on the process and rules described in chapter 6. In addition, the following rules specific to this study were applied:

1. Any discussion of gestures or functionality that did not specifically relate to music was ignored.
2. Any functionality or gesture that was not clearly described in the transcription was ignored to avoid ambiguity.
3. A conceptual metaphor was only identified when the mapping between the functionality or gesture and musical concept was clearly defined.

4. In cases where the mapping and conceptual metaphor were the same but the underlying image schema differed, this was counted as a separate mapping for the purposes of the analysis.
5. Any references to C, D, E, etc. were assumed to refer to musical notes unless harmony or modality was specifically mentioned.

8.4 Discussion

As can be seen from tables 8:1 and 8:2 above, the participants mapped a number of conceptual metaphors to elements of the jumpsuit design. However, of the four conceptual metaphors provided as part of the materials for the study, only three were identified in the transcriptions; A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY, HARMONIC PROGRESSION IS MOVEMENT and HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH (see table 8:3 below). As the participants were free to use as much or as little of the supporting materials as they wished, this is perhaps to be expected. Interestingly, the reference to the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH in the second design sketch of study session two was initially identified from the discussions between the participants as the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT. However, when the design sketch was reviewed and the instruction “tracing *paths* with hands – change inversion + intervals” was identified, the initial analysis was updated to refer to the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH reflecting the use of the term “*paths*”.

Table 8:3 - Table showing how the conceptual metaphors provided as part of the materials for the study were used in the design sketches.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	Session	In Design?
A CHANGE IN CHORD IS A CHANGE IN CENTRE OF GRAVITY	Change centre of gravity	BALANCE	2	2	YES
A CHANGE IN CHORD IS A CHANGE IN THE	Change centre of gravity	BALANCE	1	1	NO

Conceptual Metaphor	Gesture / Functionality	Image Schema	Transcription Mapping Frequency	Session	In Design?
CENTRE OF GRAVITY					
HARMONIC PROGRESSION IS MOVEMENT	Move body	MOMENTUM	1	2	YES
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Moving arms	SOURCE-PATH-GOAL	1	2	YES
HARMONIC PROGRESSION IS MOVEMENT	Movement	MOMENTUM	5	2	YES
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	23	1	YES
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	2	2	NO

The design sketches produced in the study sessions used contrasting interaction models for the jumpsuit suggesting that the materials did not appear to constrain the resulting designs to any particular degree. This variation in approach to the design of the jumpsuit led to different conceptual metaphors and interaction styles being emphasised in the designs. Table 8:4 below lists all of the conceptual metaphors that appeared in the design sketches.

Table 8:4 - Table showing the conceptual metaphors used in the design sketches and their associated musical concepts.

Musical Concept	Conceptual Metaphor	Session
Chord/harmonic structure	A CHORD IS A WHOLE WHOSE PARTS ARE NOTES	2 (Sketch 2)
	A CHORD IS A CONTAINER FOR NOTES	2 (Sketch 2)
Harmonic progression	A CHANGE IN CHORD IS A CHANGE IN CENTRE OF GRAVITY	2 (Sketch 1)
	A CHANGE IN DIRECTION IS A CHANGE IN CHORD	1
	A CHANGE IN DIRECTION IS A CHANGE IN KEY	1
	A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD	1

Musical Concept	Conceptual Metaphor	Session
	HARMONIC PROGRESSION IS CHANGE IN BALANCE	2 (Sketch 1)
	HARMONIC PROGRESSION IS MOVEMENT	2 (Sketches 1 and 2)
	HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	1, 2 (Sketch 2)
Movement	A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	1
Musical structure	A NOTE IS AN OBJECT	2 (Sketch 2)
Playing music	STARTING A SECTION IS UP	1
	STARTING MUSIC IS CONTACT	2 (Sketch 2)
	STOPPING A SECTION IS UP	1
	STOPPING MUSIC IS CONTACT	1
	STOPPING MUSIC IS MOVEMENT	1
Rhythm	A CHANGE IN SPEED OF CONTACT IS A CHANGE IN TEMPO	2 (Sketch 1)
	A CHANGE IN SPEED OF MOVEMENT IS A CHANGE IN TEMPO	1
	A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY	1
Storing music	SAVING MUSIC IS AN OBJECT	2 (Sketch 2)
	SAVING MUSIC IS CONTAINMENT	1
Timbre	A CHANGE IN TIMBRE IS A CHANGE IN THE CENTRE OF GRAVITY	1
Volume	VOLUME IS DISTANCE	1

Reviewing tables 8:1 through 8:4 together, we can see that the design sketch from the first study session allowed users to control harmonic progression by walking and changing direction supported by the conceptual metaphors A CHANGE IN DIRECTION IS A CHANGE IN CHORD, A CHANGE IN DIRECTION IS A CHANGE IN KEY and A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD. In contrast, the second design sketch from the second study session included containment relationships as well as movement. Based on this design sketch, users would use a pocket on the jumpsuit to contain groups of note objects making up a chord and control the intervals and inversions in the chord by moving their arms, providing finer control over the structure of an individual chord. This interaction style is supported by the conceptual metaphors A

CHORD IS A WHOLE WHOSE PARTS ARE NOTES, A CHORD IS A CONTAINER FOR NOTES and HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH.

Based on the results shown in tables 8:1 and 8:2, we can see that the frequency with which a conceptual metaphor mapping appeared in the conversations between participants did not necessarily reflect whether or not the mapping was included in the final design sketch. For example, the conceptual metaphor A CHORD IS AN OBJECT was discussed frequently by the participants in study session two but was not included in the final design and was instead superseded by the conceptual metaphor A CHORD IS A CONTAINER FOR NOTES which was accepted after only one reference in the discussion. There are a number of possible reasons for this discrepancy. For example, it could indicate that some mappings appeared to provide better affordances than others, perhaps based on the participants' prior experiences of, or preferences for, other music interaction designs, and thus required less discussion. The participants could have been encouraged to choose specific mappings due to dependencies created by aspects of the design. Alternatively, it may indicate the importance the participants placed on exploring all aspects of a possible interaction to ensure that the resulting design supported the required functionality in an intuitive manner. In any event, the lack of correlation between the frequency with which a conceptual metaphor mapping appeared in the discussions and its subsequent inclusion in the design sketches needs to be taken into consideration when choosing which mappings should be used to implement a prototype system. The design of the prototype system will be discussed in the following chapter.

The concept of balance, prompted by the inclusion of the conceptual metaphor A CHANGE IN CHORD IS A CHANGE IN THE CENTRE OF GRAVITY, was discussed in both study sessions and associated with changing tempo, timbre and harmonic progression. In the first study session, the participants rejected the association between balance and harmonic progression and instead opted to associate balance with tempo and timbre. In the second study session, the participants associated balance with harmonic

progression as part of their first design solution. However, since the first solution was then discarded in favour of developing the second solution that did not include any direct references to balance or centre of gravity, it is unclear whether or not the participants would have retained this functionality as part of their final design. When taken into account with the results of the earlier studies discussed in chapters 5 and 6, this does suggest that balance may not be a natural mapping for harmonic progression. However, further exploration would be required to explore this hypothesis since it is possible that the association between musical concepts and balance may take place at a lower level that is not readily expressed during discussion or through bodily movement (see chapter 6 section 6.3.3 for a wider discussion on the lack of references to the BALANCE image schema in earlier studies).

Further analysis of the results revealed that the participants often explored multiple mappings for a conceptual metaphor. For example, in the first study session, the participants mapped the conceptual metaphor A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY to swaying backwards and forwards, swaying left and right and balancing. The participants finally chose to use swaying backwards and forwards to alter the tempo. Similarly, one interaction was often associated with more than one conceptual metaphor. For example, in the first study session, clapping was associated with the conceptual metaphors STARTING A SECTION IS CONTACT and STOPPING A SECTION IS CONTACT. However, in the end, the participants rejected both of these mappings. Again this could indicate that the participants found some mappings to be more natural with respect to musical concepts than others.

8.5 Limitations

The study discussed in this chapter attempted to investigate the extent to which conceptual metaphors could be used to inform design proposals made by domain experts. Specifically we explored whether domain experts could map conceptual metaphors to elements of an interaction design during design discussions without necessarily requiring any prior

knowledge of Conceptual Metaphor Theory. However, this study was limited in the following respects. Only two study sessions were carried out with two participants each. Further study sessions with other participants would have produced additional design sketches that may have revealed alternative conceptual metaphor mappings, thus increasing the options for developing a prototype system based on the designs. The participants were asked to produce sketches for one design goal, namely a jumpsuit, which supported few musical actions. Increasing the number and variety of musical actions supported or allowing the participants to choose their own design goal may have also revealed alternative mappings.

8.6 Conclusions

In this chapter we have explored how conceptual metaphors can be used to inform design proposals. We carried out a study asking domain experts to design an interactive wearable jumpsuit for creating chord progressions using a set of materials derived from pre-selected conceptual metaphors. The results of the study indicated that the participants did map conceptual metaphors to elements of the jumpsuit design. The design sketches produced by the two study sessions used contrasting interaction models and emphasised different conceptual metaphor mappings. The mappings were not always one to one and one conceptual metaphor may have been mapped to a number of elements of the jumpsuit design and vice versa. Furthermore, the frequency with which the participants discussed a conceptual metaphor mapping did not appear to influence whether or not the mapping appeared in the final design sketch. This is particularly relevant for the next stage of this research, which involves developing and evaluating a prototype system based on the results of the study discussed in this chapter. The design, development and subsequent evaluation of the prototype system are discussed in the following chapter.

9 Building a Prototype Based on Conceptual Metaphor-Influenced Designs

9.1 Overview

In the previous chapter we explored the extent to which conceptual metaphors relevant to music could be used to inform design proposals made by domain experts. This involved carrying out a study in which domain experts were asked to design an interactive jumpsuit for creating and modifying harmonic progressions. Recall that the participants were provided with a set of materials derived from relevant conceptual metaphors as a framework for making their design proposals. In the present chapter, we carry out an initial assessment of the extent to which this approach could result in useful and usable implementable designs. To this end, we built and evaluated a prototype system, as described in detail in this chapter, based on the results of the design studies. This chapter also acts as a case study for integrating the results of a design created using the process described in the previous chapter into a consistent and usable prototype system. Due to various practical and pragmatic considerations, as explained in full below, a comprehensive assessment of the results of the design studies would be beyond the scope of this present research. However, this chapter provides a rich case study detailed enough to identify key issues, highlight limitations, and illuminate the results of the design process detailed in the previous chapter.

Two practical limitations affecting the present chapter are worth noting straight away. Recall that the participants who took part in the design study produced *three* design sketches (see section 8.3 in the previous chapter). Due to time and resource limitations, a single prototype system was built and evaluated drawing on elements of all three of the design sketches. Furthermore, for practical reasons, given that developing an interactive jumpsuit that could detect movement and gestures would require the integration of multiple electronic components and more development time than was available, it was decided to use a dance mat as the controller for the prototype system augmented with an

iPhone/iPad to be held in the user's hand (see figure 9:1 below). A standard games controller dance mat with nine squares and two buttons has the merit of allowing easy identification of the user's position with respect to a central location while avoiding complications introduced by accelerometers and magnetometers. Such potential complications include calibration issues or erroneous readings caused by inadvertent movements made by the user. While a dance mat is much simpler to implement than an interactive jumpsuit, many (though not all) of the conceptual metaphors, image schemas and actions identified in the previous chapter can be applied equally well to both devices, as explored in detail in section 9.2.1 below. Similarly, the dance mat can be used to detect many (if not all) of the movements that a hypothetical jumpsuit wearer might make with their legs, feet or their whole body. At the same time, an iPhone or iPad can be used to detect the equivalent of rudimentary hand actions. Thus, a dance mat and iOS device are adequate (if not ideal) for our stated purposes of identifying key issues and limitations, and illuminating the design process described in the previous chapter.



Figure 9:1 - Photograph of the prototype system in use. As can be seen from the photograph, the dance mat has nine squares and two buttons located at the top of the dance mat.

The design, implementation and subsequent evaluation of the prototype system, including the justification for the decisions made during the prototype design phase, are discussed in the following sections.

9.2 Designing the Prototype System

Based on the design sketches and the analysis of the results of the design study discussed in the previous chapter, we chose a number of conceptual metaphor mappings for

implementation as part of the prototype system. As the design of the prototype system was developed, some of the mappings were subsequently refined. The design of the prototype system is discussed in the sections below.

9.2.1 Initial Selection of Conceptual Metaphor Mappings

One important outcome of the analysis of the results of the design study, as discussed in the previous chapter, was the identification of mappings between conceptual metaphors and elements of the jumpsuit designs. These mappings were identified through analysis of the transcription of the discussions among the participants (see tables 8:1 and 8:2 in section 8.3.1 in the previous chapter for a complete list of all of the identified mappings). For the purposes of the present study, these mappings were reviewed in order to select those most suited for implementation in the prototype system. Firstly, any mappings described by the participants and identified in the transcriptions that did *not* appear in any of the three design sketches were excluded. Next, any mappings that were not related to the main goal of creating and modifying chord progressions were excluded. The remaining mappings were then assessed based on the following criteria:

1. Relation to the goal of creating and modifying harmonic progressions.
2. Feasibility of implementation.
3. Ease of use.

Any remaining mappings that did not satisfy these criteria were excluded, leaving the subset of mappings shown in table 9:1 below. Table 9:2 below lists the excluded mappings.

Table 9:1 - Table showing the mappings chosen for implementation as part of the prototype system.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Sketch Implementation	Design Session
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Walking	SOURCE- PATH-GOAL	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
A CHANGE IN DIRECTION IS A	Change direction	LEFT-RIGHT	Step forward – relative Step backwards – parallel	Session 1

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Sketch Implementation	Design Session
CHANGE IN CHORD			Rotate left – sub dominant Rotate right - dominant	
A CHANGE IN DIRECTION IS A CHANGE IN CHORD	Change direction	FRONT-BACK	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	Walking	SOURCE-PATH-GOAL	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	FRONT-BACK	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	LEFT-RIGHT	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Change direction	SOURCE-PATH-GOAL	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right - dominant	Session 1
STOPPING MUSIC IS CONTACT	Slap leg	CONTACT	Slap leg	Session 1
SAVING MUSIC IS CONTAINMENT	Put hand in pocket	CONTAINER	Put hand in pocket	Session 1
HARMONIC PROGRESSION IS MOVEMENT	Move body	MOMENTUM	Star jumps	Session 2 Design 1
STARTING MUSIC IS CONTACT	Hit object	CONTACT	Hit object in pocket	Session 2 Design 2

Table 9:2 - Table showing the rejected conceptual metaphor mapping from the design sketches.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Session	Reason for Rejection
A CHANGE IN SPEED OF MOVEMENT IS A CHANGE IN TEMPO	Walking	MOMENTUM	Session 1	Non-essential functionality.

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Session	Reason for Rejection
VOLUME IS DISTANCE	Move fingers	UP-DOWN	Session 1	Non-essential functionality.
A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY	Sway forwards and backwards	FRONT-BACK	Session 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to maintain balance. Relies on user having a good sense of balance.
A CHANGE IN TEMPO IS A CHANGE IN THE CENTRE OF GRAVITY	Change centre of gravity	BALANCE	Session 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to maintain balance. Relies on user having a good sense of balance.
A CHANGE IN TIMBRE IS A CHANGE IN THE CENTRE OF GRAVITY	Sway left and right	LEFT-RIGHT	Session 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to maintain balance. Relies on user having a good sense of balance.
A CHANGE IN DIRECTION IS RETURNING TO A PREVIOUS CHORD	Move both thumbs	FRONT-BACK	Session 1	The user will necessarily have to move their arms to press buttons on the jumpsuit which could complicate the detection of thumb movements associated with harmonic progression.
STOPPING MUSIC IS MOVEMENT	Move one hand	MOMENTUM	Session 1	Use of hands superseded by contact. Music players generally use a button press to start and stop music, therefore use of CONTACT seems more natural and more easily identifiable to

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Session	Reason for Rejection
				users.
STARTING A SECTION IS UP	Raise one hand	UP-DOWN	Session 1	Non-essential functionality.
STOPPING A SECTION IS UP	Raise both hands	UP-DOWN	Session 1	Non-essential functionality.
A NOTE IS AN OBJECT	Tangible object	OBJECT	Session 2 Design 2	Use of tangibles complicates implementation of the jumpsuit, as we would need to detect different shapes and locations of objects.
SAVING MUSIC IS AN OBJECT	Tangible object	OBJECT	Session 2 Design 2	Use of tangibles complicates implementation of the jumpsuit, as we would need to detect different shapes and locations of objects.
HARMONIC PROGRESSION IS MOVEMENT	Move body	MOMENTUM	Session 2 Design 1 and 2	General movement superseded by walking.
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Moving arms	SOURCE-PATH-GOAL	Session 2 Design 2	Use of arms superseded by walking. The user will necessarily have to move their arms to press buttons on the jumpsuit that could complicate the detection of arm movements associated with harmonic progression.
A CHANGE IN CHORD IS CHANGE IN CENTRE OF GRAVITY	Change centre of gravity	BALANCE	Session 2 Design 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to maintain balance. Relies on user having a good sense of balance.
HARMONIC PROGRESSION IS CHANGE IN BALANCE	Stand on one leg	BALANCE	Session 2 Design 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to

Conceptual Metaphor	Gesture / Functionality	Image Schema	Design Session	Reason for Rejection
				maintain balance. Relies on user having a good sense of balance.
HARMONIC PROGRESSION IS CHANGE IN BALANCE	Balance on both legs	BALANCE	Session 2 Design 1	Detection of current centre of gravity could prove complex as user may be continuously adjusting to maintain balance. Relies on user having a good sense of balance.
A CHANGE IN SPEED OF CONTACT IS A CHANGE IN TEMPO	Clapping	CONTACT	Session 2 Design 1	Non-essential functionality.
A CHORD IS A CONTAINER FOR NOTES	Pocket	CONTAINER	Session 2 Design 2	Use of tangibles complicates implementation of the jumpsuit, as we would need to detect different shapes and locations of objects.
A CHORD IS A WHOLE WHOSE PARTS ARE NOTES	Tangible object	PART-WHOLE	Session 2 Design 2	Use of tangibles complicates implementation of the jumpsuit, as we would need to detect different shapes and locations of objects.

Now that the mappings most suitable for implementation in the prototype system have been systematically identified, it is instructive to review these mappings in more detail. From the mappings shown in table 9:1 above, eight distinct conceptual metaphors can be identified:

- HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH
- A CHANGE IN DIRECTION IS A CHANGE IN CHORD
- A PIECE OF MUSIC IS MOVEMENT ALONG A PATH
- A CHANGE IN DIRECTION IS A CHANGE IN KEY
- STOPPING MUSIC IS CONTACT

- SAVING MUSIC IS CONTAINMENT
- HARMONIC PROGRESSION IS MOVEMENT
- STARTING MUSIC IS CONTACT

These eight conceptual metaphors were associated with five separate actions from the design sketches developed by the participants:

- Stepping/rotating to select a chord
- Slapping a leg
- Putting a hand in a pocket
- Star jumps
- Hitting an object in a pocket

As noted earlier, for reasons of practicality, it was necessary to simplify the implementation of these actions. However, where possible, the essence of the original design was retained. Table 9:3 below shows the initial high-level plan for implementing each conceptual metaphor mapping.

Table 9:3 - Table showing the implementation of the selected actions. For the purposes of clarity, where the participants associated one conceptual metaphor with multiple gestures that resulted in the same implementation within the design sketch, only one such mapping is included in the table below.

Conceptual Metaphor	Design Sketch Implementation	Planned Prototype Implementation
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right – dominant	Step forward – relative Step backwards – parallel Step left – sub dominant Step right - dominant
A CHANGE IN DIRECTION IS A CHANGE IN CHORD	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right – dominant	Step forward – relative Step backwards – parallel Step left – sub dominant Step right - dominant
A PIECE OF MUSIC IS MOVEMENT ALONG A PATH	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right – dominant	Step forward – relative Step backwards – parallel Step left – sub dominant Step right - dominant
A CHANGE IN DIRECTION IS A CHANGE IN KEY	Step forward – relative Step backwards – parallel Rotate left – sub dominant Rotate right – dominant	Step forward – relative Step backwards – parallel Step left – sub dominant Step right - dominant

Conceptual Metaphor	Design Sketch Implementation	Planned Prototype Implementation
STOPPING MUSIC IS CONTACT	Slap leg	Press button
SAVING MUSIC IS CONTAINMENT	Put hand in pocket	Press button
HARMONIC PROGRESSION IS MOVEMENT	Star jumps	Step forward – relative Step backwards – parallel Step left – sub dominant Step right - dominant
STARTING MUSIC IS CONTACT	Hit object in pocket	Press button

A number of the implementation decisions noted in table 9:3 above were influenced by a single practical consideration. Namely, as itemised above, a number of the implementations chosen by the participants in the design study involved stepping or rotating in a specific direction. Given that a dance mat controller allows easy identification of the user's *location* rather than the *direction* the user is facing, it was necessary to select an implementation for the prototype system that was more congruent with a location-based interaction model. Therefore, rotation left and right was replaced with stepping left and right to select the dominant and sub dominant chords. This change impacted the conceptual metaphors HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH, A CHANGE IN DIRECTION IS A CHANGE IN CHORD, A PIECE OF MUSIC IS MOVEMENT ALONG A PATH, A CHANGE IN DIRECTION IS A CHANGE IN KEY and HARMONIC PROGRESSION IS MOVEMENT. Figure 9:2 below shows the result of this decision with respect to the mappings between the squares on the dance mat and musical chords.

	Relative	
Sub-dominant	<i>Central</i>	Dominant
	Parallel	

Figure 9:2 - Figure showing the chord mappings for the dance mat controller.

Similarly, as the dance mat controller had superseded the jumpsuit design for the purposes of the prototype system, alternative implementations were required for actions that involved interacting directly with the jumpsuit. Therefore, the original

implementations in the design sketches for the conceptual metaphors STARTING MUSIC IS CONTACT and STOPPING MUSIC IS CONTACT were replaced with button presses. In the case of SAVING MUSIC IS CONTAINMENT, the original action of placing a hand in the pocket of the jumpsuit was also replaced by pressing a button.

In order to enable the user to create and modify harmonic progressions, the need for additional functionality of a pragmatic nature not previously identified in the design study was identified:

- The ability to create a new harmonic progression.
- The ability to easily return to the home key.

Similarly, given the practical constraints of using a dance mat as the primary controller for the prototype system, a distinction had to be made between the functionality to *play* as opposed to *select* chords based on movement around the dance mat (this requirement is discussed in detail in the next section). Thus, three additional conceptual metaphors were identified as shown in table 9:4 below.

Table 9:4 - Table showing the additional conceptual metaphors required to support the implementation of the prototype system.

Conceptual Metaphor	Gesture/Functionality	Image Schema
CREATING A NEW HARMONIC PROGRESSION IS CONTACT	Make contact	CONTACT
PLAYING A CHORD IS CONTACT	Make contact	CONTACT
RETURNING TO THE HOME KEY IS CONTACT	Make contact	CONTACT

The conceptual metaphor CREATING A NEW HARMONIC PROGRESSION IS CONTACT was planned to be implemented as a button press. Alternative options were identified for implementing the conceptual metaphors PLAYING A CHORD IS CONTACT and RETURNING TO THE HOME KEY IS CONTACT. These options are discussed in the following sections. More generally, for reasons of practicality, the initial high-level plans for implementing some of the identified conceptual metaphor mappings were further refined as the design progressed and the functionality afforded by a dance mat

controller was explored further. These various options and refinements are discussed in the following section.

9.2.2 Refining the Prototype Design

As the design for the prototype system progressed, a number of alternative possibilities were identified to allow the user to understand and control the functionality of the prototype system. This led to further refinements of the conceptual metaphor mappings described in tables 9:3 and 9:4 above. All of the refinements described below arise essentially from following through and reconciling the implications of the design choices made by the participants as part of the design study with the modifications made as a result of the pragmatic implementation constraints, such as the use of the dance mat as the primary controller. Table 9:5 below lists the various options for refinement that were considered.

Table 9:5 - Table showing the different options for further refining the conceptual metaphor mappings

Conceptual Metaphor	Musical Action/Function	Option 1	Option 2
HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH	Chord selection	Walk from one square to another	Stay in one central location and tap on another square
	Central square	Central square represents the tonic chord	Central square is neutral (no harmonic relevance)
	Tonic chord selection	User defines the current tonic chord	System automatically calculates the current tonic chord with no user intervention
PLAYING A CHORD IS CONTACT	Playing chords	Play a chord on foot tap	Play a chord on button press

The benefits and drawbacks of each of the options are discussed in the sections below.

9.2.2.1 Chord Selection

Two options were considered to enable the user to select a chord. According to the first option, chord selection would be achieved by walking from one square to another. By contrast, in the case of the second option, the user would stay in a central location and

select chords by tapping on another square (typically by balancing on one foot and tapping with the other foot). Since a standard dance mat has nine squares, there are a limited number of locations the user can either walk to or tap on. Consequently, unless a mechanism can be provided to allow the user to change the tonic key, the user will only be able to access a limited number of chords. This would be an unfortunate limitation when creating harmonic progressions. Fortunately, there is a simple way round this, though it applies far better to one of the two broad chord selection approaches than the other. Under the second design option (“tap to select”) where the user stays in a central location and taps on squares to select a chord, the use of multiple taps, as opposed to single taps, on a given location could greatly expand the number of selectable chords. Note that this approach is broadly analogous to the design discussed by the participants in the first design study session (see chapter 8 section 8.3) where the user would rotate a number of times to select a particular chord. This idea of multiple taps translates less well to the first of the two design options (“walk to select”). The problem is that shifting ones weight from one location to another generally requires at least two steps (one for each foot), but can easily unintentionally involve additional steps for example when adjusting stance. Consequently, any implementation of multiple taps adapted for “walk to select” creates problems of false positives for both designer and user. Therefore, it was decided to implement the second option of tapping on squares to select chords. Thus in the key of C major, tapping on the left square would select the sub-dominant chord, F major. Tapping again would select the next sub-dominant chord, Bb major, and so on.

9.2.2.2 Central Square

As it had been decided to implement chord selection by placing the user in one central location and asking them to tap on another square to select the next chord in the progression, it was then necessary to decide whether or not the central square where the user was located would have a specific function within the system. Two options for the central square were considered; (a) the central square represents the tonic chord and (b) the

central square is a neutral place to stand or balance on one foot between actions and has no harmonic relevance. Since multiple taps within the same square would incrementally select the next chord, in the first option, the user would have to mentally map any changes to the tonic back to the central square. Furthermore, if the user is standing in the central square while tapping on other squares, it might prove difficult for the user to reselect the tonic chord, as it could be technically complex to detect the difference between the user standing on the central square with both feet and returning one foot back to the central square after tapping on another square. Therefore it was decided to keep the central square harmonically neutral.

9.2.2.3 Tonic Chord Selection

Two options for selecting the current tonic chord were considered; the user selects the current tonic chord and the system automatically changes the tonic chord when the user selects the next chord. In a system where the user selects the tonic chord, the user would need to have some understanding of what the tonic or home key was. Since the original premise was to develop a system to assist musical novices in creating harmonic progressions, this would seem an unreasonable requirement. However, in a system that automatically changes the tonic chord each time the user selects a new chord, the user need not be concerned with the tonic chord. So for example, starting on C major, if the user then selected the sub-dominant chord (F major), the system would automatically update the tonic to F major. Selecting the relative chord (F minor) would cause the system to update the tonic to F minor and so on. This option better reflects the design produced by the participants in the first design study session (see chapter 8 section 8.3). Therefore, it was decided to enable the system to automatically update the tonic chord based on the user's chord selection. To support this implementation and allow the user to return back to the very first tonic chord before any chord selections were made, it was chosen to implement the conceptual metaphor RETURNING TO THE HOME KEY IS CONTACT via a button press.

9.2.2.4 Playing Chords

Two options were considered to enable the user to play the selected chord, playing the chord when the user taps on a square and playing the chord on pressing a button. Since it had been decided to implement chord selection by tapping on a square, if the selected chord was also played at the same time as tapping on the square, the user would only be able to play the selected chord once, as tapping on the square again would select the next chord. This model would also result in additional chords that were only selected for the purposes of moving to another chord being sounded. This would force the user to maintain a mental picture of the current chord and make decisions about what to do next from hearing the selected chord once. Therefore, it was decided to implement a button press to enable the user to play the selected chord.

9.2.3 Resulting Prototype System Design

Based on the refinements to the conceptual metaphor mappings discussed above, the final design of the prototype system was as follows. The system will initially have the tonic chord set to C major. The user is located on the central square of the dance mat and selects a chord by balancing on one foot tapping their other foot on another square. This action will automatically update the current tonic chord to the selected chord (see figure 9:2 above). Multiple taps on the same square will incrementally select another chord based on the function of that square. In order to play the currently selected chord, the user must press a button. To reset the tonic back to the initial tonic chord of C major, the user must press another button.

Based on this design, any given chord can be reached by more than one set of moves. This gives useful flexibility and compensates for any limited understanding of harmonic relationships on the part of the user. For example, the harmonic progression C major – F major – G major could be recreated by the following two sets of actions shown in table 9:6 below. Although the two options for recreating the harmonic progression are similar, the actions for selecting C major differ.

Table 9:6 - Table showing two different options for recreating the harmonic progression C major - F major - G major.

User Action	Option 1	Option 2
0	Default starting position (C major)	Default starting position (C major)
1	Press button to play chord (C major)	Press button to play chord (C major)
2	Tap left (F major)	Tap left (F major)
3	Press button to play chord (F major)	Press button to play chord (F major)
4	Tap right (C major)	Press button to return to default starting position (C major)
5	Tap right (G major)	Tap right (G major)
6	Press button to play chord (G major)	Press button to play chord (G major)

9.3 Implementing the Prototype System

An application was written in the Processing language (Fry and Reas 2012) in order to process the user's interactions with a dance mat. The dance mat was connected via USB to a computer running the Processing application. As noted earlier, given that multiple taps were chosen to *select* chords from an extended the space of chords, taps cannot also be used to *sound* chords. The problem is that this would require the sounding of chords not intended for sounding but used only as a 'stepping stone' to get to other chords. Consequently, some means was needed to sound the currently selected chord. Similarly, a simple action was needed to return to the default tonic chord. One way of providing both functions would be to use two buttons on the dance mat provided for miscellaneous actions (see figure 9:1 above). However, this seemed inelegant. Consequently, a hand held iOS application was developed to provide this functionality. The iOS application was developed using the TouchOSC (hexler.net 2012) framework and communicated with the Processing application running on the computer via a wireless network. In addition, the Processing application sent status updates and selected chord information to the iOS application to provide feedback to the user.

Table 9:7 below lists all of the functionality available in the prototype system and how a user will access this functionality. Figures 9:2 and 9:3 show a screenshot of the iOS application and chord mappings on the dance mat controller respectively.

Table 9:7 - Table showing the prototype functionality and how the user can access it.

Action	User Action
Create new harmonic progression	Press “New Sequence” ⁸ button on application
Select chord	Tap square on dance mat
Play selected chord	Press “Play Chord” button on application
Return to default starting position	Press “Return to Home Chord” button on application
Play harmonic progression	Press “Play Current Sequence” toggle button on application
Save harmonic progression	Press “Save Sequence” button on application

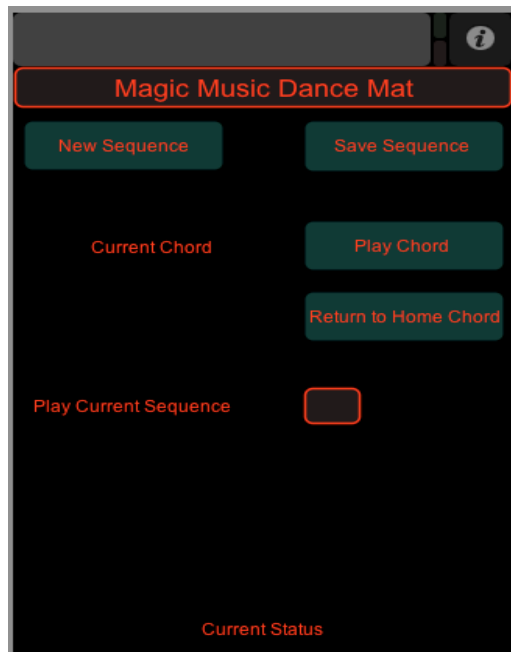


Figure 9:3 - Screenshot of the iOS application built using the TouchOSC framework.

	Relative	
Sub-dominant	<i>Neutral</i>	Dominant
	Parallel	

Figure 9:4 - Figure showing how the squares on the dance mat controller were mapped to chords.

9.4 Evaluating the Prototype

Recall that the purpose of the present chapter is to help assess the extent to which the design approach of the previous chapter could result in useful and usable designs.

So far we have filled in necessary details in the design and implemented a prototype system based on the results of the previous chapter. In the next step, the prototype system

⁸ It was decided to use the term “chord sequence” in place of the term “harmonic progression” in the user interface of the prototype system as it was felt that this term would be more accessible to users with less experience of musical terminology and concepts.

was evaluated for usefulness and usability. A short evaluation study was designed. The study is discussed in the following sections.

9.4.1 Study Design

9.4.1.1 Participants

Given that the stated purpose of the design process in the previous chapter was to design a system to be used by musical novices, ideally, at least from one point of view, one might expect that participants in the evaluation study would be musical novices. However, this would give rise to an unintended problem: it would be hard for novices to articulate any problems with the usefulness of the prototype system in a musically informed way. By contrast, participants with some prior musical experience would have enough domain knowledge to articulate the nature of any problems and to provide constructive feedback - both with regards to the prototype system and the tasks they would be asked to carry out. Consequently, it was decided to recruit participants with musical experience.

Three participants were recruited to take part in the study. At the beginning of the study session, the participants were asked to fill out a short questionnaire to gather information about their musical experience. Their answers revealed that all the participants played two or more instruments and had experience of either playing in bands or singing in choirs. Of the three participants, one was not able to read music notation. Two of the participants had experience of composing music while the third participant was the only participant to hold a formal qualification in music.

9.4.1.2 Study Materials

After completing the questionnaire and prior to beginning the study tasks, the participants were provided with some basic training in using the prototype system. The training consisted of a short document explaining the functionality of the system, how to create a short harmonic progression using the system and a glossary of terms. The training document can be found in Appendix B. No other study materials were provided.

9.4.1.3 Tasks

The study was split into two separate tasks. Unlike the studies discussed in previous chapters, the participants worked through the tasks alone, as there was no specific requirement to encourage conversation and discussion.

In the first task, the participants were asked to recreate a harmonic progression consisting of the following chords:

- C major
- G major
- G minor
- G major
- E minor
- A minor
- C major
- F major
- G major
- C major

The participants were free to attempt the tasks as many times as they wished but could only save one harmonic progression.

In the second task, the participants were asked to create a short harmonic progression consisting of approximately six chords of their choosing. The participants were free to create as many harmonic progressions as they wished but could only save one harmonic progression.

At the end of the study session once the two tasks had been completed, each participant was asked to complete a retrospective questionnaire regarding their experiences of using the prototype system.

9.4.2 Study Results

Three study sessions were carried out, one with each participant. Each study session lasted less than one hour and was video and audio recorded. The video recordings of the first task, where participants were asked to recreate a predefined harmonic progression, were analysed to ascertain the actions each participant carried out in order to complete the task. Any errors and subsequent corrective actions were noted along with any alternative actions the participants carried out in order to select a chord in the progression. Figure 9:5 below shows the number of errors made by each participant while table 9:8 below details the incorrect actions, subsequent corrective actions and any unexpected actions carried out by the participants while completing task one. The second participant who was unable to read music notation made the most errors and, in two cases, carried out a large number of alternative actions to reach the required chord when one or two taps in the appropriate location would have sufficed.

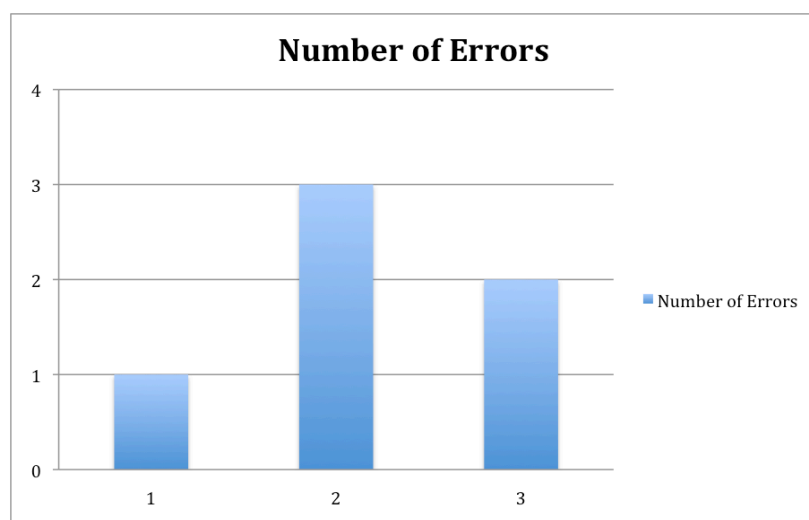


Figure 9:5 - Chart showing the number of errors made by each participant in task one.

Table 9:8 - Table showing incorrect actions, subsequent corrections and any alternative actions carried out by the participants in order to select a specific chord as part of task one.

Session	Chords/Function	Errors	Incorrect Actions	Corrections	Alternative Actions	Comments
1	C major	0	N/A	N/A	N/A	
	G major	0	N/A	N/A	N/A	
	G minor	0	N/A	N/A	N/A	
	G major	0	N/A	N/A	G minor > C minor > C major > G major	Did not appear to expect the parallel button

Session	Chords/Function	Errors	Incorrect Actions	Corrections	Alternative Actions	Comments
	G major	0	N/A	N/A	G minor > C minor > C major > G major	to switch from minor to major initially
	E minor	1	G major > C major	C major > G major > E minor	N/A	Corrected mistake fairly quickly and easily
	A minor	0	N/A	N/A	N/A	
	C major	0	N/A	N/A	N/A	
	F major	0	N/A	N/A	N/A	
	G major	0	N/A	N/A	N/A	
	C major	0	N/A	N/A	N/A	
	Save sequence	0	N/A	N/A	N/A	Incorrectly chose Play Chord instead of Play Sequence
2	C major	1	Did not 'play chord' so this was not added to the sequence	N/A	N/A	Appeared to assume he was already in C major therefore did not need to add this
	G major	0	N/A	N/A	N/A	
	G minor	0	N/A	N/A	N/A	
	G major	0	N/A	N/A	N/A	
	E minor	0	N/A	N/A	G major > D major > A major > E major > B major > F# major > C# major > G# major > D# major > A# major > F major > C major > G major > D major > A major > E major > E minor	

Session	Chords/Function	Errors	Incorrect Actions	Corrections	Alternative Actions	Comments
	A minor	0	N/A	N/A	E minor > B minor > F# minor > C# minor > G# minor > D# minor > A# minor > F minor > C minor > G minor > D minor > A minor	
	C major	1	A minor > C major > C minor	N/A	N/A	Error not corrected
	F major	1	C minor > F minor	F minor > F major	N/A	Played F minor chord so this was added to sequence
	G major	0	N/A	N/A	N/A	
	C major	0	N/A	N/A	N/A	
	Save sequence	0	N/A	N/A	N/A	Did not play sequence
3	C major	0				
	G major	0				
	G minor	0				
	G major	0				
	E minor	0				
	A minor	2	E minor > B minor B minor > F# minor	F# minor > B minor minor > E minor minor > A minor		
	C major	0				
	F major	0				
	G major	0				
	C major	0			Home Chord	
	Save sequence	0				Played sequence successfully

In the second task, the first and second participants were able to create a chord sequence relatively easily. However, the third participant made three attempts to create a harmonic progression that she considered satisfactory. Unfortunately, a defect occurred in

the prototype system during the third study session that resulted in the system being unable to playback a harmonic progression. This may have contributed to the third participant's problems creating a satisfactory harmonic progression.

When answering the post study questionnaire, all three participants stated that they found it easy to use the prototype system to create harmonic progressions and that they enjoyed using the prototype system. However, opinion was divided on whether or not they would use the prototype system to create harmonic progressions in favour of another system in the future. Only the second participant (who also had the most problems completing the first task and was not able to read music notation) stated that they would use the prototype system to create harmonic progressions in favour of another system in the future.

9.5 Discussion

Through the development and evaluation of the prototype system we have explored whether mapping conceptual metaphors to elements of an interaction design as part of a design process can result in useful and usable designs. Unfortunately, as time and resources only allowed for the development of one prototype system, it was not possible to explore all of the mappings identified from the sketches produced in the design study discussed in the previous chapter. Furthermore, to ensure the feasibility of the implementation, it was decided to use a dance mat as a controller. The change to the controller required some alterations to the identified mappings; however, where possible, the essence of the identified mappings was retained.

Based on the results of the evaluation study, the participants were able to successfully create harmonic progressions. The participants also indicated that they enjoyed using the prototype system with one participant commenting that the prototype system “provides a nice quick way to demo progressions”. Despite this encouraging feedback, the participants did note problems with the design of the prototype system, for example the inability to preview a chord before adding it to the current harmonic

progression (currently playing a chord automatically adds it to the current harmonic progression). Certainly an ability to preview a chord could prove useful when exploring possible avenues for continuing or modifying a harmonic progression. This functionality was not included in the design sketches produced in the earlier design study and was not identified as an additional feature required to support the implementation of the prototype system.

Other problems that were identified included the lack of a dance mat function to return to the default tonic chord (this function was provided by the iOS application) and the lack of control over voice leading in the resulting progressions (all of the chords were played and recorded in root position). With regards to the lack of control over voice leading, this is perhaps more of a concern to an experienced musician rather than a domain novice who is unlikely to be aware of such technicalities of musical structure. The third participant summed up this problem commenting that:

“It sounds a bit odd and ‘plonking’ as all the chords are in root position. But it gets easier the more you use it. Perhaps more useful for someone with little music background to help see related chords? That said, perhaps it also gives you ideas you might not have thought of.”

An ability to alter the inversions and intervals used in the selected chord was identified in one of the design sketches produced in the second session of the earlier design study.

However, this feature was not deemed critical for a domain novice and was subsequently abstracted into a more general ability to select chords. Further evaluation studies involving domain novices would be required to ascertain the importance of such a feature for this user group.

In any event, the results of the evaluation study suggest that using conceptual metaphors as a framework for designing a system can result in usable designs. However, further studies would be required to contrast such an approach with other design techniques such as conceptual design. Such studies are outside of the scope of this present research.

9.6 Reflections on the Conceptual Metaphor-Influenced Design Process

Reflecting on the conceptual metaphor-influenced design process discussed in this and the previous chapter, we conclude that the method does indeed hold promise. However, the omission of some features deemed to be important by participants in the evaluation study, indicates that, similar to other design techniques, a conceptual metaphor-influenced approach should be part of a wider user-centred design process that would encourage iterative refinement of the design.

Without carrying out comparison studies with alternative design techniques such as conceptual design, participative or cooperative design or rapid prototyping, it is not possible to ascertain whether or not conceptual metaphor-influenced design provides a better framework for translating user requirements and conceptual models into interaction designs than other approaches. We do however suggest that conceptual metaphor-influenced design should form part of an interaction designer's toolbox and that a good understanding of the principles of conceptual metaphor-influenced design can only enhance a designer's ability to develop useful and usable designs.

9.7 Limitations

The prototype system and subsequent evaluation study were limited in a number of respects. Firstly, the prototype system itself was limited as it was designed using a subset of the features and conceptual metaphor mappings included in the three design sketches produced in the design study discussed in chapter 8. If time and resources had allowed, a better approach would have been to implement all three of the designs and contrast these as part of a larger evaluation study. Furthermore, as a dance mat was used as the controller for the prototype system, some of the conceptual metaphor mappings that were chosen to be implemented had to be modified to work successfully with the system. Thus it was not possible to ascertain whether the mappings as originally designed were usable.

The evaluation study was limited with respect to the number of participants. Furthermore, despite the initial premise of the designing a system for musical novices as

discussed in chapter 8, the evaluation study involved participants with prior musical experience as constructive feedback from experienced musicians was prioritised.

Unfortunately this meant that there was no evidence to confirm whether the prototype system and the conceptual metaphor mappings implemented by the system were usable by musical novices. Further evaluation studies with participants with limited musical background would be required in order to explore this.

9.8 Conclusions

The purpose of this present chapter was to help assess the extent to which the design approach of the previous chapter could result in useful and usable designs. We have explored this by firstly building a prototype system based on the results of the previous chapter and, secondly, evaluating the prototype system for usefulness and usability. We have discussed compromises made during the design phase of the prototype system, in particular the choice of an alternative controller for the system and the resulting modifications and refinements that were made to some of the conceptual metaphor mappings in order to utilise the alternative controller in a consistent and usable manner.

Through carrying out a short evaluation study of the prototype system we have explored whether the resulting system can be used successfully to create harmonic progressions. Although the evaluation produced some encouraging results, some omissions in the prototype system were identified. One of the omissions, the ability to control voice leading, had been identified in one of the design sketches produced in the earlier design study but had been abstracted into the more general requirement for chord selection. As such a feature may not be used or even needed by musical novices, further evaluations would need to be carried out to explore the requirement for this feature further.

Based on the results of the evaluation study, it does appear that with some minimal training, participants with prior musical experience were able to create harmonic progressions with relative ease. However, it remains to be seen whether musical novices would have the same level of success using the prototype system. We conclude that

conceptual metaphor-influenced design does hold promise as a technique for interaction design and suggest that interaction designers should consider this approach as complementary to other design methods that they may already employ.

10 Conclusions

10.1 Overview

This thesis has prototyped a methodology for applying conceptual metaphors to the analysis and design of interactions for manipulating complex abstractions. There is a particular focus on those domains where many users lack effective means to conceptualise and articulate relevant abstractions. Tonal harmony is an excellent example of such a domain and is used as an extended case study throughout the thesis.

This thesis presents prototype methodologies for: the elicitation and identification of relevant conceptual metaphors; the analysis of interaction designs using conceptual metaphors; the application of conceptual metaphors to the design process; and the integration of such designs into working interfaces. In order to develop and ground these methodologies, the thesis addresses the following research questions:

1. How are conceptual metaphors revealed in conversations between musicians?
2. What methods can be used to elicit conceptual metaphors relevant to music?
3. How can conceptual metaphors be used to inform interaction designs for music?

The focus on the systematic analysis of *conversations* between musicians (as opposed to the written word) reflects the fact that previous research aimed at the analysis of conceptual metaphors in the domain of music has often focused either on anecdotal or unspecified evidence, or has focused on the analysis of discourse about music drawn from text books and musicological works (see section 10.4 below). However, such texts are generally only read by musicians who have followed a strict academic education in music. Even for those musicians who have read such texts, it is unclear the extent to which their everyday speech about music is grounded in academic discourse of this kind.

10.2 Contributions to Knowledge

This thesis has made five principal contributions to knowledge as detailed in the following sections.

10.2.1 Methodology for the Identification of Conceptual Metaphors from Conversations Between Musicians

This thesis presents a systematic methodology for analysing conceptual metaphors

revealed in conversations between musicians. This methodology was prototyped in an empirical study of expert musicians discussing an excerpt of a musical score (documented in chapter 5), and further refined during the exploration of the second research question (documented in chapter 6) as summarised in the sections below.

10.2.1.1 Prototyping of the Methodology

In the study documented in chapter 5, three experienced musicians were provided with an excerpt of a musical score of a sacred motet and asked to work collaboratively to answer a series of questions on the structure of the excerpt and their emotional responses to the excerpt. The conversation between the participants was recorded and analysed to identify the image schemas utilised by the participants when describing musical concepts. Relevant conceptual metaphors were then extrapolated from the image schemas, taking into account the surrounding context of the conversation. The initial methodology is documented in detail in sections 5.3.1 and 5.3.2 in chapter 5.

10.2.1.2 Refinement of the Methodology

The methodology for the identification of conceptual metaphors from conversations between musicians was refined as the result of a further study documented in section 6.3 in chapter 6. In the study, groups of participants were asked to discuss firstly, an excerpt of a musical score they brought with them to the study and secondly, a musical score provided to them. The conversations between the participants were recorded and analysed to identify firstly the image schemas and secondly, the conceptual metaphors used by the participants. The methodology for identification was refined from the earlier version by systematically documenting the ‘trigger’ words used to identify image schemas, along with any relevant decisions and rules around the identification process. This refined methodology is documented in detail in sections 6.3.2.1 and 6.3.2.2 in chapter 6.

10.2.2 Methods for Eliciting Conceptual Metaphors Relevant to Musical Concepts

This thesis presents methods for systematically guiding conversations between musicians for the purposes of eliciting conceptual metaphors for musical concepts. These methods were explored in three empirical studies where groups of musicians were asked to describe musical excerpts using a variety of prompts. These studies were documented in chapters 5 and 6.

In the first study (documented in chapter 5), three experienced musicians were provided with an excerpt of a musical score of a sacred motet and asked to work collaboratively to answer a series of questions on the structure of the excerpt and their emotional responses to the excerpt. In the second study (documented in section 6.2 in chapter 6), pairs of participants were asked to describe musical excerpts using firstly, a set of words and secondly, a set of images. Both the words and image prompts were chosen to represent specific image schemas. In the third and final study (documented in section 6.3 in chapter 6), groups of participants were asked to discuss firstly, an excerpt of a musical score they brought with them to the study and secondly, a musical score provided to them. In all studies, the conversations between the participants were recorded and analysed. The approach taken in each study is summarised in table 10:1 below. Aspects of the design of the studies highlighted three issues as summarised in the sections below.

Table 10:1 - Summary of representation media, prompts and participants in the three studies.

Study	Chapter	Participants	Representational Media	Prompts
1	Chapter 5	3 highly skilled and experienced musicians	Musical score	N/A
2	Chapter 6, section 6.2	6 musicians with varying levels of skill and experience	Audio files	Task 1 – Words Task 2 - Images
3	Chapter 6, section 6.3	7 musicians with varying levels of skill and experience	Task 1 – musical score and optional demonstration Task 2 – musical score, audio recording and optional demonstration	N/A

10.2.2.1 Choice of Representational Media

The first issue emerging from the elicitation studies concerned the effects of using a *particular representation* of music to elicit discourse, a case in point being the use of an excerpt of a musical score to stimulate conversation. In both the first and third studies, this approach generated ample opportunities to elicit relevant conceptual metaphors, but the question arose of how the choice of medium might affect not just the *quantity*, but also the *quality* of conceptual metaphors elicited. A musical score (in contrast to say an audio recording) visually reifies and emphasises certain aspects of musical structure. For example a bar is clearly seen to **contain** notes (CONTAINER), a piece of music can be seen to **have** a number of parts (PART-WHOLE) and a melody evidently **starts** on one note and **finishes** on another (SOURCE-PATH-GOAL). Thus, the strong visual emphasis of particular image schemas is likely to have influenced the discussions among the participants in the first and third studies, implicitly highlighting certain aspects of musical structure.

By contrast, the use of audio as a representation format does not provide the strong visual emphasis of particular aspects of musical structure in comparison with a musical score. This may have contributed to the lack of detail in the discussions between the participants in the second study⁹.

10.2.2.2 Study Prompts and Directions

The second issue highlighted by aspects of the design of the elicitation studies relates to the prompts and directions given to the participants during the study. Additional (non-musical) prompts were provided to participants only in the second study. However, the use of words and images as prompts for discussion appeared to encourage the participants in this study to make associations between the excerpts and social or historical contexts, or to build a story around the excerpts, rather than to focus on musical concepts. Participants

⁹ Due to the lack of detail in participants' discussions, there were limited opportunities to identify relevant conceptual metaphors. Thus, any detailed analysis of the second study was abandoned. This decision is discussed in more detail in section 6.2.2 in chapter 6.

may also have been influenced in their focus by the lack of clear direction given with respect to the type and level of detail of musical concepts to be discussed. Thus, the opportunities to elicit relevant conceptual metaphors from the conversations between participants in this study were curtailed. By contrast, the first and third studies, despite not providing any prompts for the participants, provided clearer direction on the musical concepts to be discussed. Thus, the absence of potentially extraneous non-musical prompts fostered more opportunities to elicit relevant conceptual metaphors.

10.2.2.3 Background of Participants

The third issue highlighted by aspects of the study design concerned the effects of the musical backgrounds of participants. The participants in the first study were highly skilled and experienced musicians, used to analysing musical scores. They were experienced at identifying aspects of musical structure from musical scores in order to influence their own performances or to direct others. However, the participants in the second and third studies had varying levels of musical ability and knowledge and it is likely that some would have had little or no experience in the detailed structural analysis of musical excerpts. Thus, the range of ability and experience may have had an impact on the level of detail of conceptual metaphors elicited.

10.2.2.4 Guidance for the Design of Future Elicitation Studies

Based on the three elicitation studies undertaken, we are able to offer guidelines for the elicitation of relevant conceptual metaphors from conversations as follows. Tasks should be designed to focus participants on the *specific aspects* of structure under consideration. Prompts that may encourage participants to build narrative stories around domain concepts should be avoided. In the domain of music, for many purposes, a good choice of representation for highly skilled participants is a musical score, since these reify and provide visual emphasis of many aspects of abstract musical structure that are ripe for image-schematic representation. We recommend giving participants clear directions on which aspects of structure should be discussed. To ensure the participants are comfortable

articulating the concepts to be discussed with enough detail, where possible we also recommend involving participants with high levels of skill and knowledge in the domain under consideration. Designing studies based on these recommendations should create superior conditions for eliciting relevant conceptual metaphors.

10.2.3 Methodology for the use of Conceptual Metaphors to Evaluate Music Interaction Designs

This thesis presents a methodology for using conceptual metaphors to analyse existing music interaction designs. This methodology was prototyped through the execution of a study that systematically evaluated two examples of music interaction designs (Harmony Space (1994) and GarageBand (2009)) by comparing aspects of each interaction design such as the controls, layout and behaviour with each of the conceptual metaphors listed in table 5:1 in chapter 5. This methodology is documented in sections 7.2.2 and 7.3 in chapter 7.

Although the evaluation study revealed no significant flaws in either of the interaction designs, opportunities to improve the designs by providing additional support for specific conceptual metaphors were identified. An example of this is the recently added chord trace functionality in Harmony Space to provide additional support for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH. In addition, we were able to identify areas of tension in the designs where support for one task had been enhanced at the expense of the other, for example the lack of explicit support for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH in GarageBand. Such information could be used by interaction designers to assess the extent to which a design provides adequate support for the specified system requirements.

10.2.4 Methodology for the use of Conceptual Metaphors to Inform the Design Process

This thesis presents a methodology for applying conceptual metaphors to the design process. This methodology was prototyped through the execution of an empirical design

study (documented in chapter 8) and the integration of the results of the design study into a prototype system (documented in chapter 9). These aspects are discussed in the sections below.

10.2.4.1 Conceptual Metaphor-Influenced Design

The first stage of the methodology for applying conceptual metaphors to the design process was to generate design proposals. This was achieved by carrying out a design study. In the study (documented in chapter 8), groups of musicians were asked to develop design proposals for a wearable gesture-controlled jumpsuit, using a design framework based on conceptual metaphors. The design framework enabled domain experts to map conceptual metaphors to elements of an interaction design without requiring knowledge of Conceptual Metaphor Theory. The development of the framework is documented in sections 8.2.2 and 8.2.3 in chapter 8. The conversations between the participants were recorded and analysed to identify the ways in which the participants mapped conceptual metaphors to elements of their designs. The analysis is discussed in detail in section 8.3.1 in chapter 8.

The study was successful and the groups of participants produced three separate design sketches. At the same time, the analysis of the conversations between the participants as they developed their designs raised various issues. In particular, the frequency with which the participants discussed a mapping between a conceptual metaphor and an element of the interaction design did not necessarily reflect whether or not that mapping was included in their final design. Similarly, the mappings the participants discussed were not always one to one, with one conceptual metaphor being suggested for multiple elements of the design and vice versa. We posit that the participants may have considered some mappings to offer more natural affordances within the context of gestural interactions than others.

10.2.4.2 Integration of Design Proposals into a Prototype System

The methodology for applying conceptual metaphors to the design process was extended through the presentation of a pilot study in which the results of the design process were

integrated into a working prototype system (documented in chapter 9) for the purposes of exploring the feasibility of the design proposals.

The development of the prototype system raised yet more interesting issues, particularly with respect to the need for pragmatic modifications and refinements to be made to the system to address various development constraints and issues of practicality. Specifically, the complications involved in developing a gesture-controlled jumpsuit that could identify the wearer's location and direction, resulted in the pragmatic decision to implement the prototype system using simpler means, namely a dance mat games controller. The use of a dance mat games controller fixed the position of the user within the boundaries of the dance mat itself, providing fewer affordances for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH than a jumpsuit. The functionality to save a harmonic progression, originally associated with the user putting their hand in a pocket (CONTAINMENT) in the design proposal, was modified to pressing a button on a handheld tablet computer (CONTACT). Additional functionality of a pragmatic nature that would be required of a working system (e.g. to initiate the creation of a new harmonic progression), but which was not identified during the design study, was added to the system and implemented through button presses on a handheld tablet computer. Although the differences between the design proposals developed during the design study and the resulting prototype system meant that it was not possible to test the mappings in their original configuration, they do reflect the realities of system development. Namely, that resource and (sometimes unanticipated) technological constraints will often result in compromises between the designer's ideal and the finished system.

Once the prototype system had been implemented, a short evaluation study was carried out to assess the usefulness of the prototype for the purposes of creating tonal harmonic progressions. Although the participants in the evaluation study were able to create tonal harmonic progressions using the system with varying degrees of success, the

evaluation revealed some omissions in the system. Thus, we conclude that, on reflection, a conceptual metaphor-influenced approach to design should be part of a wider user-centred design process that would encourage iterative refinement of the design and thus provide opportunities to resolve issues associated with compromises and omissions in the resulting prototype system.

10.2.5 Validation of Conceptual Metaphors

In addition to the above contributions, we have also been able to validate a number of conceptual metaphors identified by previous studies that concentrated on the analysis of music theory texts, for example the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH as identified by Saslaw (1997-1998). This is discussed in more detail in section 5.4 in chapter 5.

10.3 Discussion of Issues Raised During the Course of this Research

The research documented in this thesis and the contributions cited in the previous sections has raised a number of interesting issues with respect to the process of identifying conceptual metaphors, representations used to elicit conceptual metaphors and the application of conceptual metaphors within interaction designs and to the design process in general. We reflect on these issues in the sections below.

10.3.1 Identification of Conceptual Metaphors

The process of identifying conceptual metaphors documented in this thesis focussed on the analysis of conversations between musicians. Transcriptions of the conversations were analysed to identify words that indicated the use of an image schema. Conceptual metaphors were then extrapolated based on the participant's comments and the context of the surrounding conversation. However, physical gestures that the participants made while discussing domain-specific concepts were not considered. Such gestures (e.g. arm movements when discussing harmonic or melodic progressions) could have provided additional evidence for the identification of image schemas and conceptual metaphors. Furthermore, the analysis of gestures made by the participants could have provided some

indications of ways in which conceptual metaphors could map to aspects of future interaction design, similarly to Antle et al.'s (2008 and 2009b) approach to the design process.

10.3.2 Conceptual Metaphors and Musical Representations

The elicitation methods considered in this thesis focussed primarily on two styles of musical representation, musical scores and audio files. As discussed at length in the previous sections, the use of audio files as the only representation format was not entirely successful for the purposes of eliciting conceptual metaphors from conversations between musicians, although some problems may have been due to other aspects of the study design. By contrast, the use of musical scores was more successful, most likely due in part to the visual emphasis afforded by a musical score of aspects of musical structure consistent with image-schematic representations. This may have encouraged the participants to reflect on such aspects. Alternative visual musical representation formats emphasise different aspects of musical structure. For example, guitar tablature explains how a piece of music should be played, indicating where the player's fingers should be placed on the frets. This type of representation emphasises chordal structures and the relationship between the music and the instrument it is played on but provides limited information on the rhythmic and melodic content of the piece of music or the distinction between different parts or voices. Figured bass notation shows the relationship between the bass line (or basso continuo) and the harmonic structure of a piece of music through the use of numbers and symbols to represent intervals between notes. This notation emphasises the harmonic relationships and progressions within a piece of music but provides limited information on the melodic content. However, as these notation systems are instrument or genre specific, they are not read or understood by all musicians. By contrast, musical score notation provides the reader with information on all aspects of musical structure and is recognised and understood by many musicians thus was a more appropriate choice for our purposes. We posit that as different notation systems emphasise different aspects of

musical structure, these will implicitly influence the participants' conversations and thus result in the elicitation of alternative conceptual metaphors.

10.3.3 Conceptual Metaphors and Interaction Design

The methodology documented in this thesis focussed on the application of conceptual metaphors to the analysis and design of interactions for music. The conceptual metaphors considered were grounded in embodied experiences, for example HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH, A KEY/CHORD IS A CONTAINER FOR NOTES, etc. However, user interface controls and interaction designs afford concepts of their own, for example pressing a button involves the CONTACT image schema while moving a slider involves the MOMENTUM, SOURCE-PATH-GOAL and UP-DOWN/LEFT-RIGHT image schemas¹⁰. Thus the user's understanding of the domain concepts incorporated within an interaction design will necessarily be influenced by the nature of the medium used to represent the concept. This is perhaps more true of interaction mediums (such as desktop-based systems) where the means of controlling and communicating with the system involves abstractions of image-schematic concepts. Consider for example the desktop version of Harmony Space (Holland 1994). In order to use the system to sound a musical chord, the user must first apply their knowledge of desktop interactions, for example the use of the mouse to locate and 'activate' areas of the screen. This type of interaction involves image-schematic concepts such as direction, force, contact and paths. Knowledge of desktop interactions is then combined with the user's comprehension of what constitutes a musical chord and how it can be sounded perhaps through experiences of seeing and hearing chords played on a piano (CONTACT). This blend of knowledge from both domains allows the user to understand and interact with the system, playing chords by using the mouse to click on the chord symbols in the key window (PLAYING A CHORD IS CONTACT). By contrast, gesture-based system

¹⁰ For further examples of the image schemas instantiated by various user interface controls, see Hurtienne (2007).

such as the jumpsuit considered in chapter 8 or the Sound Maker system designed by Antle et al. (2008) can harness bodily movements that are more representative of the image schemas used to ground the domain concepts, thus avoiding an additional layer of abstraction. Examples might include associating faster movements with a faster tempo (TEMPO IS SPEED OF MOVEMENT) or playing a piece of music through movement (A PIECE OF MUSIC IS MOVEMENT ALONG A PATH). This present research did not consider in any great detail the differences between interaction methods and how they may influence the user's overall understanding of the domain concepts they afford. However, we posit that Conceptual Blending Theory (Grady et al. 1999, Turner and Fauconnier 1995) has much to offer with respect to understanding the processes by which concepts and aspects from different domains can be blended together and interact with each other to structure knowledge.

10.3.4 Conceptual Metaphors within the Design Process

In this section, we contrast the approach taken in this thesis with established techniques in the field of human-computer interaction.

10.3.4.1 Elicitation and Identification of Conceptual Metaphors

The first stage of this research was to elicit and identify the conceptual metaphors used by musicians in conversation. This is analogous to the first stage of a user-centred design process where the designer builds up an understanding of the concepts and requirements of the domain (Preece et al. 1994, pp. 351-355). This is often done through documentation and system reviews, interviews and user observations of the existing system. However, although these approaches are useful for the purposes of developing a general understanding of the tasks, concepts, terminology and processes used in the domain, they provide limited information on how such aspects are structured. By contrast, conceptual metaphors can be used to analyse the ways in which users structure their understanding of complex abstractions. This information can then be applied to other stages of the design process as discussed in the subsections below.

10.3.4.2 Analysis of Interaction Designs Using Conceptual Metaphors

The approach to evaluation documented in this thesis is similar to other ‘expert’ evaluation techniques such as cognitive walkthrough (Stone 2001, pp. 42-43) or heuristic evaluation (Neilsen 1995). In these techniques, a user interface design or domain expert analyses a system based on pre-defined criteria. Cognitive walkthrough techniques focus on the user’s thought processes as they carry out a task, assessing how well the user can identify their next action and whether or not the system provides adequate feedback at each stage of the task. Heuristic evaluations focus on various aspects of the design as a whole system for example exploring how flexible the design is, how efficiently tasks can be carried out, and whether or not the design is consistent and conforms to agreed standards. By contrast, conceptual metaphors provide the ability to look at aspects of a design with a finer level of granularity. For example, as demonstrated in this thesis, conceptual metaphors can be used to assess whether a design supports the user’s structural understanding of the domain concepts it affords, and to identify aspects of the design where that understanding is violated. Our approach can also be used to illuminate design decisions that result in support for one task being enhanced at the expense of another. However, conceptual metaphors are less well suited to identify issues of design consistency, conformance to guidelines and visibility of information and concepts.

10.3.4.3 Applying Conceptual Metaphors to the Design Process

Well-known approaches to interaction design include personas (Pruitt and Grudin 2003), scenarios and use cases (Stone 2001, pp. 38-41), and cooperative and participative design (Preece et al. 1994, pp. 375-376). Of these approaches, the approach to design documented in this thesis is perhaps most obviously related to participative design. However, our approach involves domain experts rather than anticipated users in the design process. Our approach is supplemented by the use of simple personas and scenarios for the purposes of providing the participants in the design process with contextual information about how and when the system would be used. Generally, the use of personas, scenarios and use cases

can encourage the designer to focus on the tasks and user groups the interface is intended to support. By contrast, one distinctive advantage of a conceptual metaphor approach as documented in this thesis is to enable the designer to explore how domain concepts can be mapped to elements of an interaction design. This is particularly useful in illuminating the choice of interaction method or user interface controls. However, a conceptual metaphor approach is perhaps less well suited to addressing wider issues such as the actions required to support a specific task. Techniques such as participative design are relatively lightweight in terms of the theoretical knowledge and time required to produce reasonably satisfactory results. For example, it would not be unusual for a software developer with a little prior experience of user interface design to facilitate, or be proactively involved in, a design session with prospective users or develop prototypes for subsequent discussion and evaluation. Such techniques are relatively quick to execute and often require little preparation outside of an understanding of the requirements of the resulting system. By contrast, a conceptual metaphor-influenced design process not only requires some knowledge of the principles of Conceptual Metaphor Theory but also an understanding of the conceptual metaphors relevant to the domain under consideration. The initial development of a corpus of relevant conceptual metaphors for the domain in question would require significant research time and, depending on the context, could potentially involve user studies, document reviews and an analysis of any existing systems or processes (similar to the process described by Hurtienne et al. (2008)). Thus the initial investment in terms of theoretical knowledge and preparation time for a conceptual metaphor-influenced design process is significantly greater than for some alternative approaches, although arguably comparable to that of persona development. However, after this one-off initial investment, subsequent design processes could be conducted relatively rapidly.

10.3.4.4 Developing Prototype Systems Based on a Conceptual Metaphor-Influenced Design Process

A number of low-fi approaches to developing prototype systems for the purposes of testing the usability of a design are available, for example sketches, mock-ups and storyboards (Stone 2001, pp. 66-69), and Wizard of Oz studies (Preece et al. 1994, pp. 541-542). These approaches generally involve the facilitator responding to the user's actions and updating the system's state manually, for example by providing an updated sketch or initiating a response. By contrast, the approach taken in this thesis was to develop a fully working prototype system, whose subsequent operation did not require any Wizard of Oz-like intervention on the part of the facilitator. Still, the development of the prototype system was subject to pragmatic constraints. These led to the design being modified somewhat from the original intentions expressed by the participants in the design study. Despite the differences between the prototype system and the original design proposals, the development of a fully working prototype system afforded the opportunity to explore the feasibility of the design proposals with respect to technological and resource constraints. Using an alternative approach such as a Wizard of Oz study would have made it possible to develop a prototype system that was in certain respects closer to the intention of the design proposals. However, given the time-bound nature of harmonic progressions, a Wizard of Oz style of approach might be highly problematic in other respects. Such an approach would require someone to rapidly calculate and play appropriate chords in response to the user's movements and location. Such a simulated system would be liable to latency, instability and error. Thus, despite the admitted need for pragmatic compromises, our approach offered advantages for prototyping a gesture-driven time-bound system.

10.3.4.5 Conceptual Metaphors and the User-Centred Design Process

As discussed in the previous sections, a conceptual metaphor-based approach to eliciting domain knowledge, design, evaluation and prototype development offers the design practitioner certain distinctive benefits different from those offered by other techniques.

However, as noted previously, despite these distinctive benefits, conceptual metaphors are less well suited to certain significant aspects of design and analysis such as assessing conformance to guidelines, design consistency, efficiency and task analysis. We therefore conclude that conceptual metaphors offer the most benefit when incorporated into an iterative user-centred design process incorporating other techniques such as cognitive walkthroughs (Stone 2001, pp. 42-43), use cases (Stone 2001, pp. 38-41) and personas (Pruitt and Grudin 2003).

10.4 Relation to Other Work

10.4.1 Identification of Conceptual Metaphors

The approach to the identification of conceptual metaphors documented in this thesis contrasts with that of Saslaw (1996, 1997-1998) who focussed on analysing music theory texts, and that of Johnson and Larson (2003) who evidenced their use of conceptual metaphors to explain musical phenomena using anecdotal utterances. In both of the latter cases, limited information was provided on the methodology used to elicit, identify and validate the conceptual metaphors discussed. Other documented examples of conversation analysis exist (in domains other than music) for the purposes of identifying image schemas and conceptual metaphors (e.g. Hurtienne 2011, Treglown 1999). However, the tasks discussed in such works involve comparatively mundane and readily understood concepts such as invoice verification (Hurtienne 2011, Hurtienne et al. 2008) or file management (Treglown 1999), in contrast to the highly abstract and complex concepts in the domain of tonal harmony, that even many musicians may find hard to conceptualise and articulate.

10.4.2 Elicitation of Conceptual Metaphors

The approach to the elicitation of conceptual metaphors documented in this thesis is in contrast to the approach of Antle et al. (2009 and 2009b) where a combination of movement studies, literature reviews and pilot studies were used to elicit relevant embodied metaphors. In these studies, there was a focus on simple scalar quantities such as pitch and loudness and their application to physical gestures. The approach documented in

this thesis also contrast with approaches to elicitation documented by Hurtienne (2011) and Hurtienne et al. (2008). These approaches focus on a user interface for an existing system for carrying out a repetitive administrative task with fixed decision points. Thus, the documented methods were not well suited or practical for the purposes of eliciting relevant conceptual metaphors from conversations between musicians where the concepts under discussion often involve substantial complexity.

10.4.3 The use of Conceptual Metaphors to Evaluate Music Interaction Designs

The approach to evaluation documented in this thesis differs from that of Hurtienne (2011), Hurtienne et al. (2008), Treglown (1999) and Rohrer (1995) in two respects. Firstly, these studies considered interaction designs for comparatively straightforward concepts such as invoice verification (Hurtienne 2011, Hurtienne et al. 2008), file deletion using the trashcan (Rohrer 1995) and navigating immersive environments (Treglown 1999). Secondly, the approach to the evaluations themselves is very different. In the case of Hurtienne (2011) and Hurtienne et al. (2008), the evaluation was executed by carrying out context-of-use analysis and user observations. This enabled the authors to identify the image schemas in use and highlight shortcomings in the original system where users' expectations were violated. By contrast, Rohrer (1995) and Treglown (1999) used conceptual metaphors to explain aspects of interaction designs which users may find challenging. These approaches contrast sharply with the systematic approach to evaluating interaction designs for complex abstractions employed in this thesis.

10.4.4 The use of Conceptual Metaphors to Inform the Design Process

The approach to design documented in this thesis is in contrast to that of Hurtienne (2011) who developed two alternative designs for an invoice verification and posting system based on a context-of-use analysis and user observations of the existing system. The approach documented in this thesis also differs from that of Antle et al. (2009 and 2009b)

who utilised a series of movement studies, literature reviews and pilot studies to develop designs for three separate interactive systems.

10.5 Limitations

Limitations specific to each of the studies carried out as part of this research have been detailed in the relevant chapters. However, there are some more general limitations worth noting. All of the studies carried out as part of this research were limited in terms of the number of participants. In addition, the studies used to elicit conceptual metaphors from conversations between musicians were limited in terms of the musical representation formats used. It remains to be seen whether different representation formats would have a significant impact on the breadth and depth of conceptual metaphors elicited (see section 10.6.1.1 for suggestions for alternative representation formats). Furthermore, none of the studies carried out for the purposes of eliciting conceptual metaphors considered any physical gestures made by the participants while discussing aspects of musical structure. Such gestures may have provided validation for the identification of specific conceptual metaphors.

Although the various studies carried out to elicit conceptual metaphors from musicians revealed conceptual metaphors for a number of musical concepts, this research was primarily focused on harmonic progression and as such, the resulting prototype system did not consider other aspects of music.

10.6 Further Work

Numerous cross-disciplinary future research projects follow naturally from this work. For the purposes of illustration, we have identified two general categories of potential future work:

1. Further development of the methodology for applying conceptual metaphors to the design and analysis of music interactions.
2. Explorations of the applicability of this approach to other domains.

These categories are discussed in the sections below.

10.6.1 Further Development of the Methodology

The possibilities for further development and refinement of the methodology for applying conceptual metaphors to the analysis and design of interaction for music are extensive and cover many different aspects. These aspects are discussed in the subsections below.

10.6.1.1 Methods for Eliciting Conceptual Metaphors Relevant to Musical Concepts

Additional studies could be designed to explore the impact of the musical representations used, and the skill and experience of participants on the process of eliciting conceptual metaphors. In particular we posit that, as alternative musical notations will emphasise different aspects of musical structure, these will impact on the participants' conversations and thus the conceptual metaphors that can be elicited. We also suggest that future studies could analyse the physical gestures made by participants when discussing music as a means to provide additional validation of the conceptual metaphors identified, and for suggestions as to how these could map to elements of interaction designs.

10.6.1.2 Methodology for the use of Conceptual Metaphors to Evaluate Music Interaction Designs

The evaluation process discussed in chapter 7 could be extended to cover additional aspects of user interface design such as terminology and supporting documentation. In addition, the process could be formalised into a series of questions the evaluator must answer similar to a cognitive walkthrough (Stone 2001, pp. 42-43), or checkpoints similar to a heuristic evaluation (Nielsen 1995).

To assess fully the benefits of a conceptual metaphor-based approach to evaluation, the approach could be formally compared with other techniques such as cognitive walkthrough (Stone 2001, pp. 42-43) and heuristic evaluation (Nielsen 1995). Aspects that could be considered include the length of time taken to complete an evaluation using the technique and the amount of training in the technique the evaluator would require. As a study by Hurtienne (2011) has indicated that, with some minimal training, participants were able to apply knowledge of the FORCE image schema to their experiences of user

interfaces, we anticipate that the training overhead may not be overly discouraging. The results of the evaluation processes could also be contrasted to identify the relative strengths and weaknesses of each technique.

10.6.1.3 Methodology for the use of Conceptual Metaphors to Inform the Design Process

The framework for mapping conceptual metaphors to elements of an interaction design could be expanded upon and formalised by exploring the effect of different sets of study materials on the resulting conceptual metaphor mappings. For example, future studies could utilise alternative conceptual metaphors, provide greater direction on how conceptual metaphors can map to elements of interaction design or provide the participants with guidance on the principles of Conceptual Metaphor Theory.

Another promising avenue involves the exploration of the benefits of incorporating aspects of Conceptual Blending Theory (Grady et al. 1999, Turner and Fauconnier 1995) into the design process documented in this thesis. In particular, the conversations between the participants of a conceptual metaphor-influenced design process could be analysed to explore how the participants blended musical concepts with elements of the interaction design. We posit that this may assist with explaining why some mappings between conceptual metaphors and elements of interaction design may have appeared to the participants to provide fewer natural affordances than others (see section 8.4 in chapter 8), i.e. there were not enough correspondences between the domains for the mapping to be successful.

Alternative future directions could involve contrasting the approach documented in this thesis with other well-established design techniques such as participative design (Preece et al. 1994, pp. 375-376), personas (Pruitt and Grudin 2003) and use cases (Stone 2001, pp. 38-41). Studies could measure the initial outlay in terms of time and resources required to develop a corpus of conceptual metaphors versus the development of personas or the amount of training a facilitator would require to enable them execute the technique

effectively. Parallel studies could be carried out using both a conceptual metaphor approach and other established approaches to design and the results contrasted to explore the relative strengths and weaknesses of each technique. Further studies could also be designed to explore the benefits of incorporating conceptual metaphor-influenced design into a wider user-centred design process, utilising other design techniques and iterative feedback cycles.

10.6.1.4 Prototype Development Based on the Results of a Conceptual Metaphor-Influenced Design Process

Considering the prototype system developed as part of this research, future directions could include the exploration of whether the prototype system is useful to domain novices and whether the system could enhance domain novice's understanding of harmonic concepts. Other potential avenues for exploration include implementing multiple versions of the prototype system that utilised different sets of conceptual metaphor mappings and evaluating the usefulness and usability of each system. Another alternative direction could involve contrasting the benefits of developing a fully working prototype system versus a Wizard of Oz (Preece et al. 1994, pp. 541-542) approach to prototyping.

10.6.2 Exploration of Other Domains

Future directions of this research could involve exploring the application of the approach to design and analysis of music interactions documented in this thesis to other domains. Although we believe that many domains would benefit from a conceptual metaphor-influenced approach to design and analysis, we posit that domains where users may have difficulty in conceptualising, enacting or articulating complex abstractions would receive the most advantage. For example, the domain of graphic design utilises a number of different file formats, processes such as layering and filtering and terminologies such as airbrushing, hue, saturation, etc, all of which may appear confusing to the inexperienced or infrequent user. As well as the issues associated with managing complex file hierarchies, software developers have to understand the grammatical and syntactical structures

associated with their development language and many will also regularly deal with complex concepts such as inheritance, polymorphism and overloading. In both of these domains, the large number of complex abstractions is likely to prove challenging for both the interaction designer who must communicate the information in an understandable manner and the user who must carry out tasks effectively using the resulting software tools. Applications of a conceptual metaphor-influenced design process to these domains could take a similar approach to analysis and design as detailed in this research or involve comparisons with other design and analysis techniques. It is our belief that applying a conceptual metaphor-influenced approach to other domains will provide a more detailed overall picture of the benefits and drawbacks of such an approach in comparison with other techniques.

10.7 Concluding Remarks

In the preface to the 2002 edition of his seminal book, *The Design of Everyday Things*,

Donald Norman argues that

“...good design is also an act of communication between the designer and the user, except that all the communication has to come about by the appearance of the device itself. The device must explain itself. Even the location and operation of the controls require a conceptual model – an obvious and natural relationship between their location and the operation they control so you also know which control does what...Conceptual models are critical to good design.” (Norman 2002)

It is our hope that, by demonstrating how musicians’ domain knowledge in the form of conceptual metaphors based on universal embodied knowledge can be applied to the design and analysis of interaction designs for music, we have moved some way closer to Norman’s ideal of devices that explain themselves.

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Appendix A – Chapter 6 Study Materials

Study A – Eliciting Conceptual Metaphors Using Text and Images as Prompts

Task 1 - Task Description for Participants

In this task you will be provided with a selection of words, each printed on a separate piece of paper. You will then be played a number of short excerpts of music. After each excerpt of music has been played, you should describe the form and structure of the excerpt you have heard as if you were describing it to someone who had not heard the excerpt using the provided words to help you. You are free to choose as many of the words as you like and can add your own words using the blank cards provided. You should work together as a pair and discuss your choices with each other.

Task 2 – Task Description for Participants

In this task you will be provided with a selection of images, each printed on a separate piece of paper. You will then be played a number of short excerpts of music. After each excerpt of music has been played, you should describe the form and structure of the excerpt you have heard as if you were describing it to someone who had not heard the excerpt using the provided images to help you. When choosing an image, you should think about what the image represents as well as the content of the image. For example an image of a family picnic may represent closeness and unity. You are free to choose as many of the images as you like. You should work together as a pair and discuss your choices with each other.

Study B – Eliciting Conceptual Metaphors Using Musical Notation as a Prompt

Task 1 - Task Description for Participants

In this task you should take it in turns to briefly describe the piece of music that you have brought with you to your fellow participants. You are free to describe any aspect of the piece of music that you wish; however you may like to consider the following questions as a starting point:

- Why did you choose this piece of music?
- Can this piece of music be played on the instrument you have chosen? Can you explain why?
- Is there a particular aspect of this piece of music that particularly interests you? Can you explain why?
- Identify a melody within this piece of music and describe it.
- Identify a harmonic progression within this piece of music and describe it.
- Identify a rhythm within this piece of music and describe it.

You are free to focus on a shorter excerpt of the piece of music rather than the entire piece if you so wish. You are also free to demonstrate extracts from the piece of music on your chosen instrument to aid your description.

Once you have finished describing your chosen piece of music, the other participants will be free to comment on the description provided or on the piece of music itself or demonstrate aspects of the piece of music on their own chosen instrument.

Task 2 – Task Description for Participants

In this task you will be provided with a score and an audio recording of a piece of music chosen by the facilitator. You should take it in turns to identify an aspect of the piece of music that interests you and describe it to your fellow participants. You are free to describe any aspect of the piece of music that you wish; however you may like to consider the following questions as a starting point:

- Can this piece of music be played on the instrument you have chosen? Can you explain why?
- Is there a particular aspect of this piece of music that particularly interests you? Can you explain why?
- Identify a melody within this piece of music and describe it.
- Identify a harmonic progression within this piece of music and describe it.
- Identify a rhythm within this piece of music and describe it.

You are free to focus on a shorter excerpt of the piece of music rather than the entire piece if you so wish. You are also free to demonstrate extracts from the piece of music on your chosen instrument to aid your description.

Once you have finished describing your chosen aspect of the piece of music, the other participants will be free to comment on the description provided or on the piece of music itself or demonstrate aspects of the piece of music on their own chosen instrument.

Appendix B – Chapter 9 Study Materials

Magic Music Dance Mat Training Materials

iPad/iPhone Controls

To create a new sequence:

Click **New Sequence**

To play the current chord:

Click **Play Chord**

To return to the home chord (C major):

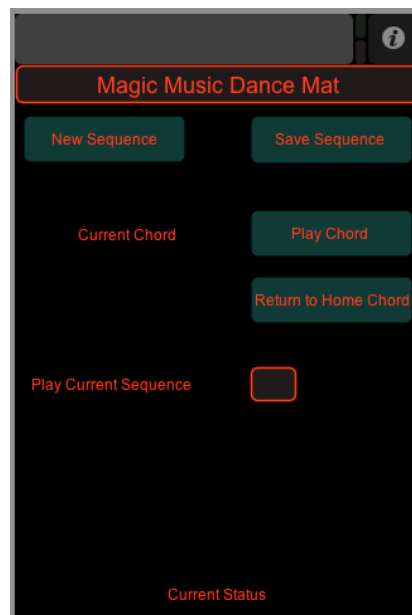
Click **Return to Home Chord**

To play the current sequence:

Click **Play Current Sequence**

To save a sequence:

Click **Save Sequence**



Dance Mat Controls

Start in the Default position.

To select a chord, tap the relevant square with your foot.

To play the selected chord, click Play Chord on the iPad/iPhone.

Not used	N/A	Not used
Not used	Select Relative Chord	Not used
Select Sub-Dominant Chord	Default	Select Dominant Chord
Not used	Select Parallel Chord	Not used

Glossary

Sub-dominant – this is the 4th chord, e.g. in the key of C major this will be F major.

Dominant – this is the 5th chord, e.g. in the key of C major this will be G major.

Relative – this is the relative chord which has the same key signature, e.g. in the key of C major this will be A minor, in the key of D minor this will be F major

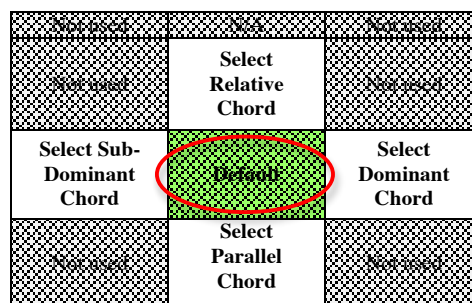
Parallel – this is the parallel chord, e.g. in the key of C major this will be C minor, in the key of D minor this will be D major

Example

To generate the chord sequence C major -> F major -> G major -> C major

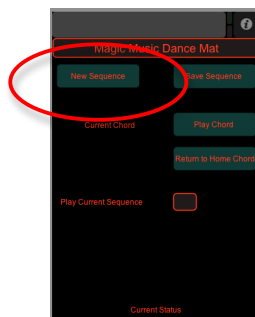
Step 1

Start in the **Default** position



Step 2

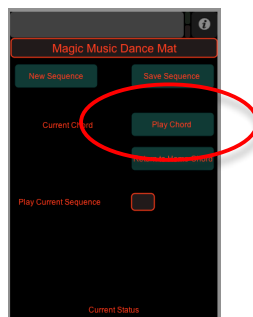
Click **New Sequence**



Step 3

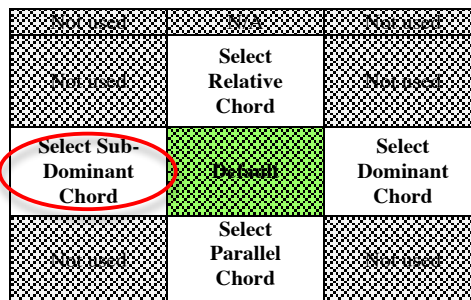
The system defaults to C major as the home chord

Click **Play Chord**



Step 4

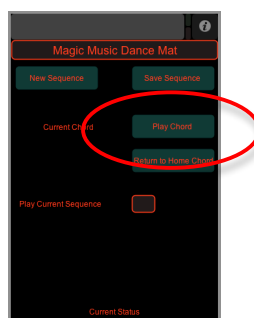
Tap left to select the sub-dominant, F major



Step 5

The system is currently in F major

Click **Play Chord**

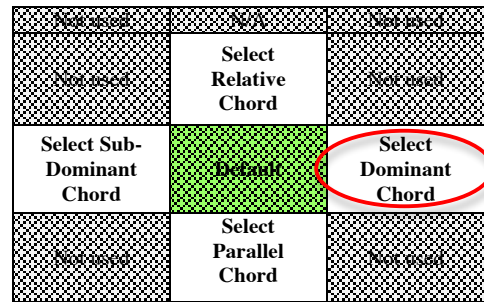


Step 6

The system is currently in F major
Tap right to select the dominant of F major, i.e. C major

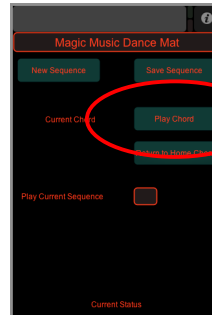
The system is now in C major

Tap right to select the dominant of C major, i.e. G major



Step 5

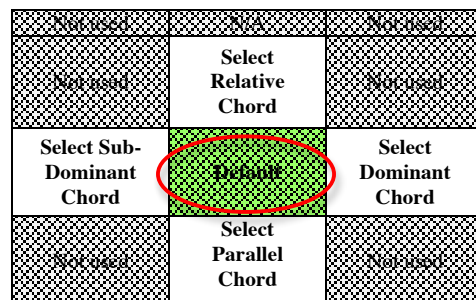
The system is currently in G major
Click **Play Chord**



Step 6

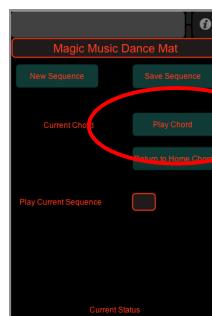
The system is currently in G major
Tap left to select the sub-dominant of G major, i.e. C major

Note an alternative solution would be to click Return to Home Chord



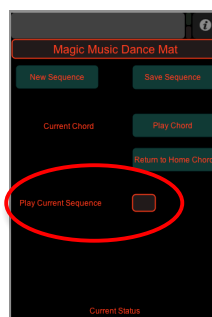
Step 7

The system is currently in C major
Click **Play Chord**



Step 8

Click **Play Current Sequence**



Evaluation Study Materials

Task 1

Use the system to create and save the following chord sequence:

C major
G major
G minor
G major
E minor
A minor
C major
F major
G major
C major

You can attempt the sequence as many times as you like but you must only save 1 chord sequence.

Task 2

Use the system to create and save a sequence of 6 chords of your own choosing. You can create as many sequences as you like but you must only save 1 sequence.